POTASH INDUSTRY

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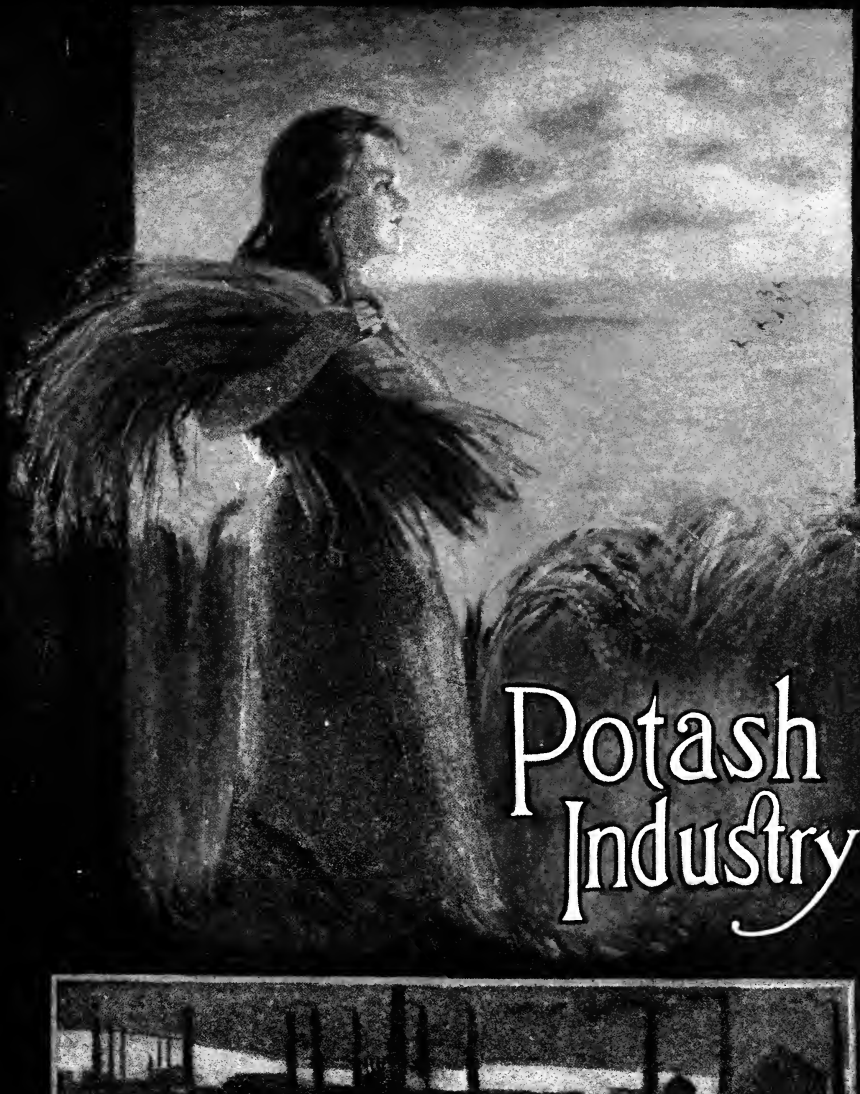
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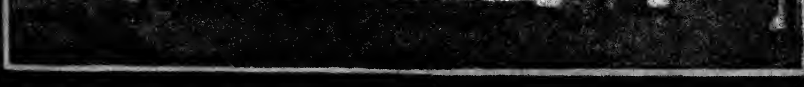

THE

POTASH INDUSTRY

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ADDRESS

Preface

THOUSANDS of American farmers use potash. Hundreds of thousands of them should use it, both for their own present and future profit and to prevent their posterity from receiving a heritage of "worn out" soils. But ashes—once the most common source of potash—are no longer to be had in quantity. Our forests are now cleared and the ash heap of the pioneer is a thing of the past, while wood as a fuel for factories and railroads has been replaced by coal and oil. Where, then, shall we turn for our needs of potash?

Man seldom feels a pressing and continuous need which Nature does not meet—and such has been the case with potash. Within the fifty years which measure alike a rapidly increasing demand for it and the practical disappearance of the old source of supply, there has been found, in one of Nature's storehouses, an inexhaustible accumulation of potash. To the discovery of the potash deposits the term fortunate can be applied, since it came in time to meet need; but the storing of the potash, when one considers the importance of this element for the welfare of our fields and its necessity in maintaining the food

supply for the rapidly increasing population of the world, the storing we must call providential. The processes of Nature, by which this accumulation was made possible, are marvelous, and the methods which man has devised to utilize the store and convert it into forms best suited to the diverse requirements of his fellows are ingenious. The many inquiries which arise concerning potash in its varied forms, prove that its users are interested in its history; therefore, this little sketch has been prepared to meet the friendly wishes of those who already appreciate potash. The story is interesting and those who read it will derive pleasure and profit.

Historical Sketch

THE town of Stassfurt, near the Harz mountains in northern Germany, has been, for many centuries, noted for its salt works. There in the early days of history, common salt was obtained by evaporating the water from its salt springs, and later, from its wells, but when mines of rock salt were discovered in other parts of Germany, the evaporation process for making salt was abandoned partly because the brine from the springs and wells generally contained, beside table salt, the salts of potash and magnesia. About sixty years ago, the Prussian Government, which owned the mines at Stassfurt, began boring for rock salt, and in 1857 found it in immense quantities 1,080 feet below the surface. Immediately above this rock salt are deposits of various potash and magnesia minerals, at first considered of little value and actually thrown away as worthless, but later destined to supply the world with potash. The agricultural value of potash became generally known about 1860, through the researches of that eminent scientist, Prof. Justus von Liebig, and in 1861 the first works for refining crude potash minerals was established at Stassfurt. Stimulated by the success attained in the use of potash as a fertilizer, the industry of mining and manufacturing its salts has grown to enormous proportions; new deposits have been discovered and mines opened, until today there are about one hundred and fifteen large mining establishments in active operation.

Origin of the Salt and Potash Deposits

THE German salt and potash beds were formed (or deposited) in ancient, geologic times. Long before history began, these minerals were laid in place by the evaporation of sea water confined in lakes, which, somewhat like the Dead Sea and Baikal Lake, were without outlet. These lakes were connected, however, with the ocean by channels, ordinarily dry, but through which the sea water was forced at times by great storms and tides. In this way fresh supplies of salt were received into these lakes, and as the climate of Europe was tropical during this formative period, the surface evaporation of the water was exceedingly rapid. As the water levels of these lakes thus sank, fresh supplies washed in from the sea, holding in solution then, as now, many salts. Evaporation carries off only pure water, so, in course of time, as more salts were entering the lakes and none going out, the water became saturated with salts until those least soluble in water began to separate from the more soluble ones and deposit themselves in more or less uniform strata. By such continued evaporation and ever increasing concentration, immense layers of rock salt and anhydrit (sulfate of lime) were formed.

As the rock salt separated and the concentration became greater, other more soluble salts began to deposit and cover it, layer upon layer, up through the mineral

polyhalit, which is composed of sulfate of lime, potash and magnesia,—kieserit, which is sulfate of magnesia,—and the "potash region," the stratum of carnallit, a compound of chlorids of potassium and magnesium. This last named stratum ranges from 50 to 130 feet in thickness, and supplies the crude salts from which the most important and concentrated potash salts are refined.

From thus referring to strata it does not follow that these deposits are in smooth, clear-cut layers. From time to time, as additional water came in from the sea, the lake water became so diluted that precipitation was arrested to a certain extent, and, later had to commence again; thus anhydrit is found in the rock salt strata, and seams of rock salt in the polyhalit and other upper layers. Potash and magnesia salts are the most soluble and, therefore, naturally found at the tops of the deposits.

Had these deposits been exposed to the action of rain water they would have been dissolved, but they were protected during geologic changes by a covering of "salt clay" impervious to water. The depth of the potash and salt deposits from the top of the upper to the bottom of the lowest stratum is some 5,000 feet. The beds underlie the extensive country reaching approximately to Thuringia on the south, to Hanover on the west and to Mecklenburg on the north, and in recent years deposits were discovered and mines opened in Elsass.

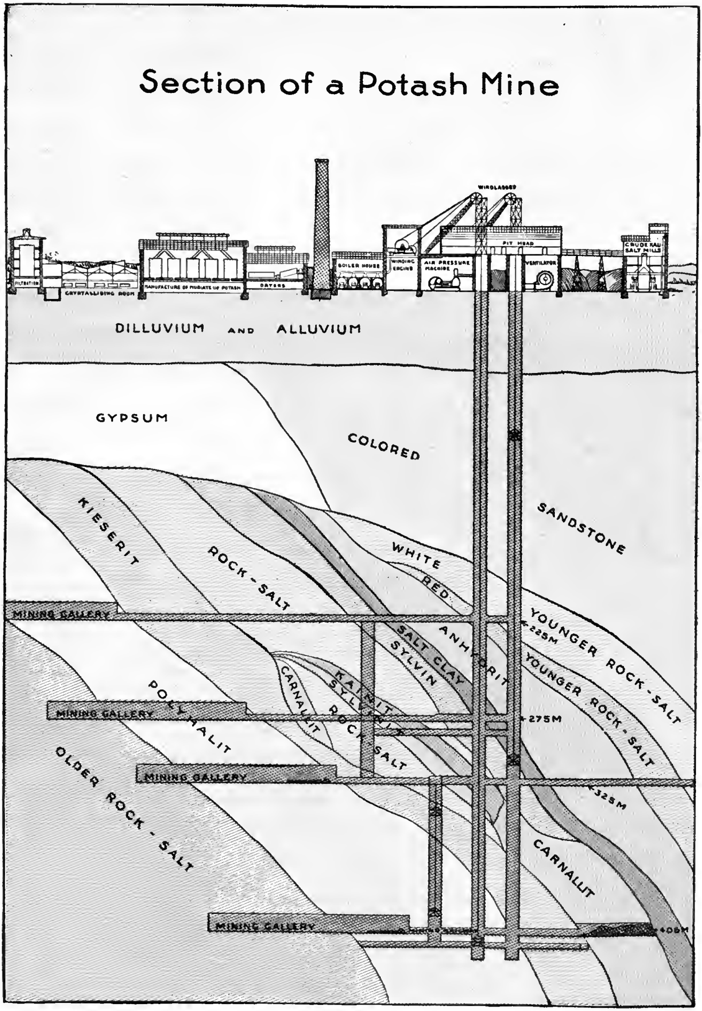
These deposits, in the order of their placing, follow well understood physical and chemical laws; and yet local conditions and geologic disturbances fixed the relative po-

sitions of strata and account for more or less apparent disturbances as shown by the diagram on page 9. At a few places surface water found access through cracks or fissures, and either carried away the potash salts or changed them into secondary products; from which action in the upper strata occur beds of kainit, sylvinit, hard-salt and other compounds of less importance.

This description, somewhat tedious to unscientific readers, becomes of surpassing interest when the enormous importance of the formation is considered. But for these peculiar geologic conditions (conditions generally termed accidental) these potash deposits could not have been formed; and vast tracts of agricultural lands, now made fertile and productive by the use of potash from this inexhaustible store, would be sterile and barren for want of it. There is no question as to this scientific fact, and thoughtful readers may well again peruse the story of these wonderful deposits and question whether a formation —all but a creation—of such importance to the human race, can be considered a mere chance,—a simple accident of nature.

Description of the Salts

SALT is the chemical name for a compound composed of an acid joined to, or combined with, a base. For example, burnt lime is a base, which, in combination with sulphuric acid, forms a salt called sulfate of lime; similarly the base sodium combined with hydrochloric acid forms the salt, sodium chlorid. This last is the compound



THE DEPTH OF THE MINING GALLERIES IS EXPRESSED IN METERS ; 1 METER EQUALS 3.281 FEET

to which, popularly, the word "salt" is applied, for sodium chlorid is our common table salt, but chemically the term is a general name for compounds produced as described above. The potash deposits contain various salts and combinations of salts, many of which contain little or no potash. Those most important as potash producers, are Carnallit, Kainit and Hardsalt.

Carnallit is a double compound of muriate of potash and magnesium chlorid with the chemical formula: $KCl, MgCl_2, 6H_2O$, is the chief source of muriate of potash and other concentrated salts, and usually occurs mixed with rock salt, kieserit, and other minerals in layers averaging more than 85 feet in thickness. The color varies, and shades through white, bright to dark red, yellow, and light to dark gray, to a watery hue. In a strong clear light the brilliancy of carnallit crystals and their varied colorings give to its mine galleries a strikingly beautiful effect. Carnallit as mined contains about 9 per cent. of actual potash. In its crude state it is used as a fertilizer only in localities which are not very far from the mines; because from its property of absorbing water, and its bulk as compared with the small percentage of potash which it contains, it is more expensive than the concentrated salts, where cartage or freight has to be considered. The deposits of carnallit are generally intersected by rock salt and often by other minerals, and are so vast in extent as to be practically inexhaustible.

Kainit is a mineral compound of chlorid of potassium and sulfate of magnesium ($KCl, MgSO_4, 3H_2O$). The commercial product does not denote a mineral of definite

composition but a mixture varying in composition according to the mines from which it is obtained and fluctuates in composition even when coming from the same mine. For this reason the potash works guarantee only the minimum amount of pure potash—12%—and no guarantee is given for the form in which the potash is present or the amount of other concomitants. It occurs in irregular deposits, and is usually red and more or less mixed with rock salt, of which it contains about 30 per cent. In its crude state it is largely used as a fertilizer, after being crushed and ground. Most of the kainit is sold in its natural state for fertilizing purposes, although a considerable part is used in the manufacture of high grade sulfate of potash and other concentrated products.

Hardsalt is similar to kainit in composition but contains less water of crystallization. It is essentially a mixture of chloride of potassium, sulfate of magnesium and chlorid of sodium and its composition is very varied. As an article of commerce hardsalt is guaranteed to contain 16 per cent. of potash (K_2O) and its uses in agriculture are identical with those of kainit.

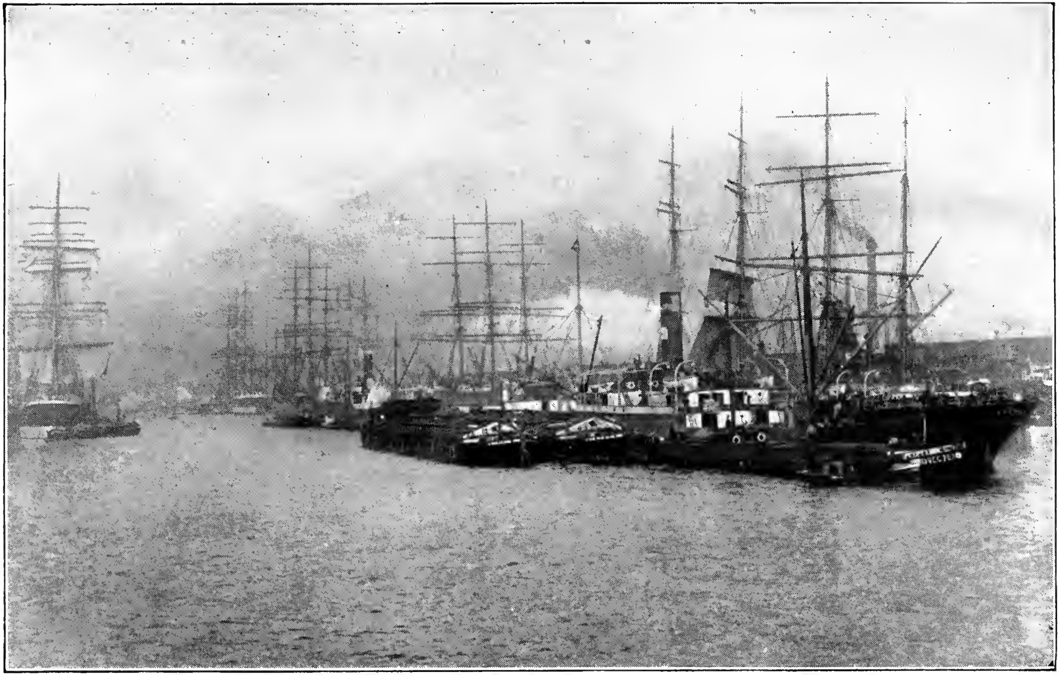
Of these three crude potash salts only kainit and hardsalt are used in the United States; on account of the freight rates the results obtained from the concentrated forms of potash as a rule pay better. Kainit is extensively used in the Coast Line States, not only as a fertilizer, but also as a manure preservative, to check attacks of injurious insects, and as a remedy against cotton disease (blight). For such purposes it is cheap and satisfactory and likely to be used in increasing quantities.

Mining the Salts

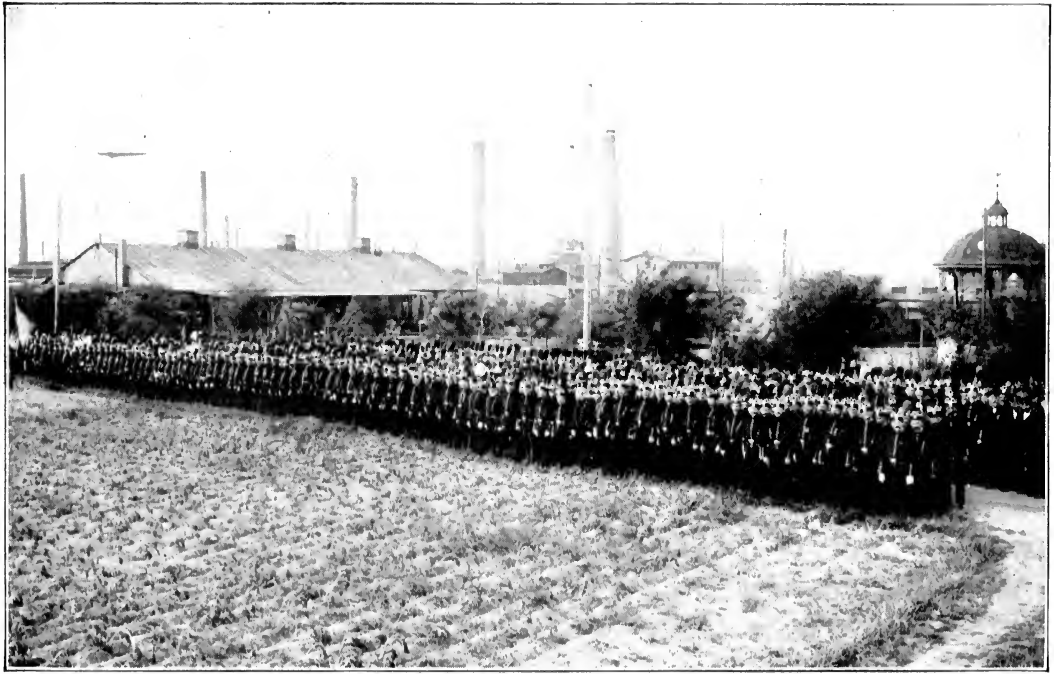
THE potash-bearing strata, from 1,200 to 3,500 feet below the earth's surface, are reached by ordinary mine shafts. In sinking these shafts, great care is taken to preserve unbroken the cap materials impervious to water, and thus to prevent the highly soluble potash-bearing salts from being rapidly leached or washed away by the surface waters. This inflow of water is made impossible by sinking iron tubes or lining the shafts with concrete. Water is the great danger in potash mining, and has destroyed valuable mines. Generally potash mines have a reserve or emergency shaft, some distance from the working shaft, protected by strong safety-pillars. Another mining difficulty is the "pillaring" or supporting the mine-roof as its mineral supports are cut away. Formerly pillars of carnallit or other salts were left for this purpose, but they disintegrated so rapidly as to be dangerous, and the safer system was adopted of completely filling up the excavations with the waste salts and rock salt. Within the mines, potash salts are broken down by blasting as in ordinary mining. In many of the works, electricity is used for motor power and in lighting. The mines are necessarily kept perfectly dry, and visitors are free from the inconvenience and discomfort usual to underground workings. The carnallit blastings tear off large blocks which are broken up by the miners and transported in small cars to the shafts, thence to be hoisted to the surface and delivered to the chemical works for grinding and further treatment.

EXTERIOR OF A POTASH MINE

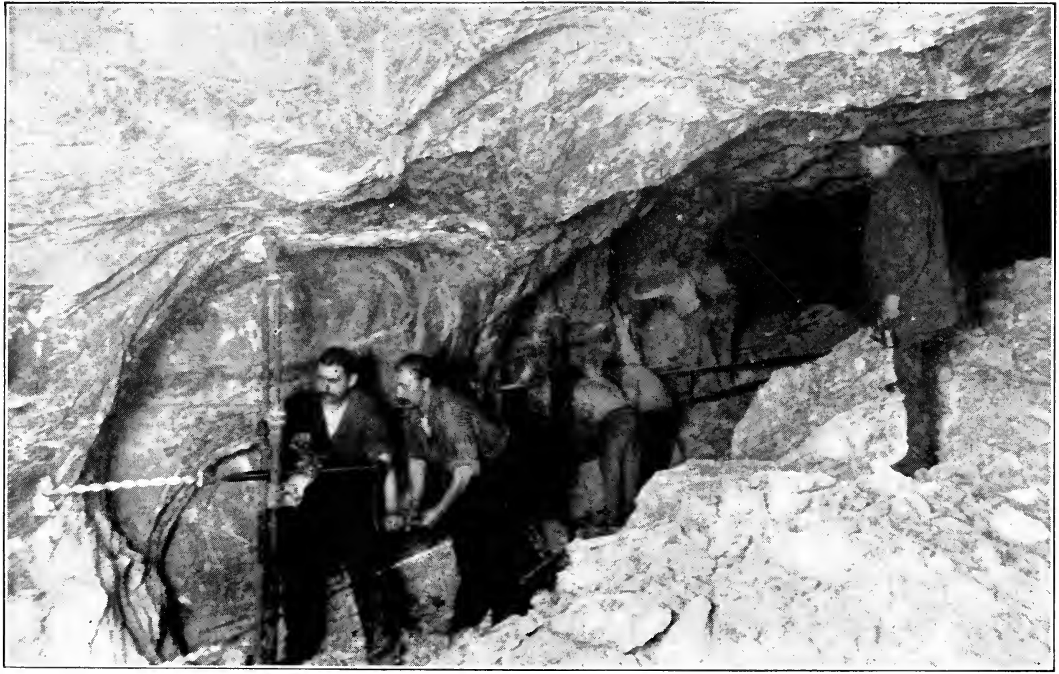
HEAD-GEAR FOR LIFTING PRODUCTS FROM THE MINES



LOADING POTASH SALTS ON OCEAN LINERS FROM BARGES

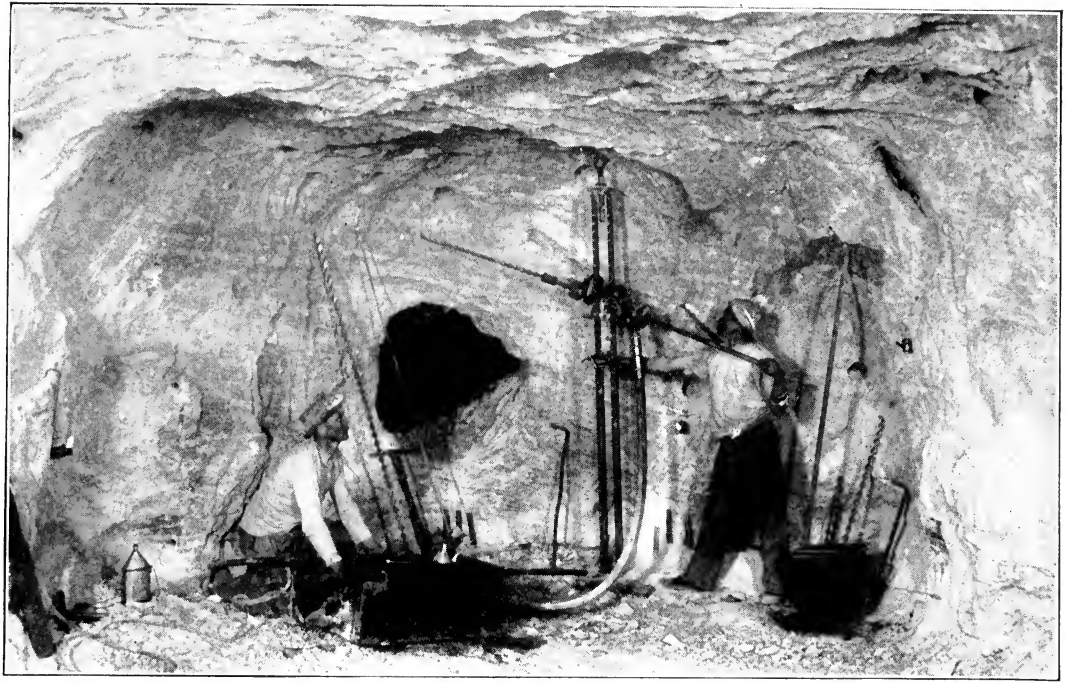


GROUP OF POTASH MINERS



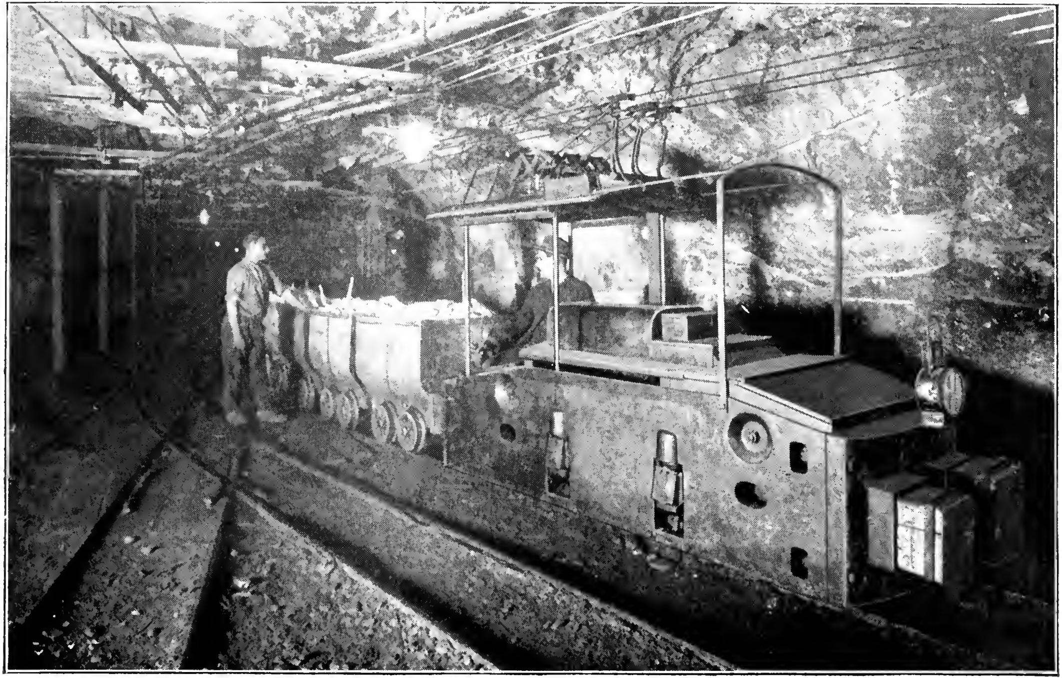
DRILLING IN POTASH MINE PREPARATORY TO BLASTING

MINING KAINIT



ELECTRICAL DRILLING MACHINE IN OPERATION

TRANSPORTING POTASH SALTS IN THE MINES BY CABLE



TRANSPORTING POTASH SALTS IN MINE BY ELECTRIC CONVEYANCES

FOOT OF ELEVATOR SHAFT

SCENE DURING LUNCH HOUR IN A POTASH MINE

Manufacturing the Concentrated Salts

AS has been intimated, at the mines are extensive and completely equipped chemical works which refine the crude salts and separate their constituents into products best suited to the various chemical industries. A most important feature of the refining is the reduction in weight by rejecting useless constituents of the salts, thus securing the valuable potash in a small bulk; an essential consideration for the man who pays the freight or handles the products. Yet to refine closely is an expensive process, and much study and great care are necessary to balance properly the amount of concentration against the diverse uses and the cost of shipping and handling the various materials. In estimating the quantity of potash in the different products, chemists are accustomed to make use of the term "actual potash," that is, oxide of potassium (K_2O). The object of this is to establish a basis of comparison of all potash salts; therefore, when "potash" is named in potash products, it is understood that the word refers to the amount of actual potash and not the quantity of sulfate or muriate of potash, as the case may be. As a matter of fact, potash is not sold commonly in the form of "actual potash" (K_2O,) but as sulfate of potash, muriate of potash, sulfate of potash-magnesia, etc. Sulfate of potash is simply actual potash chemically combined with sulfuric acid; and muriate of potash, actual potash combined with muriatic (hydrochloric) acid. The resulting salts, muriate of potash, sulfate of potash and sulfate of potash magnesia are not acid but neutral salts.

In manufacturing muriate of potash from the crude minerals found in the potash mines, lime, soda, magnesia and other salts are removed. Crude carnallit, as it comes from the mines, contains on an average 15 per cent. muriate of potash; the manufacturing process consists in separating this 15 per cent. from the 85 per cent. of other crude ores, and makes use of the chemical knowledge that these other salts are either more soluble or less soluble in water and other solutions than pure muriate of potash. The coarsely ground carnallit is "charged" into a large dissolving vat containing a boiling, saturated solution of magnesium chlorid (a by-product of the process, as shown later). The mixture is agitated thoroughly by means of a "blow-up," or live steam jet, and is boiled until it shows a degree of concentration equal to 32 degrees Beaumé. The contents are then drawn off into settling tanks, from which the clear solution is run into crystallizing vats and left three or four days to cool and crystallize, the deposit containing about 60 per cent. pure muriate of potash. The liquors drawn from the crystallizing vats are boiled down (now almost exclusively in a vacuum apparatus, but formerly in open pans), during which process some chloride of sodium and sulfate of magnesium fall out. This second solution settles and runs into crystallizing vats where practically all the potash separates, as crystals of pure artificial mineral carnallit (KCl, $MgCl_2$, $6H_2O$), which is treated precisely as was the crude carnallit and gives a nearly pure muriate of potash in one crystallization.

The crystallized muriate of potash thus produced is contaminated by chlorids of sodium and magnesium,

through adhering solutions, and these impurities are removed by a series of washings with water. The liquor from these washings of the crystals is saved and used on fresh batches of the mineral ore. The crystals of muriate of potash are dried, after washing, and are from 70 to 99 per cent. pure (KCl). The last "mother liquors," or solutions from the crystallizing vats, (from which all the potash has been separated) are used for the manufacture of bromine and chlorid of magnesium.

The muriate of potash (chlorid of potassium) manufactured is of various grades and contains actual potash in the following proportions:

Pure Muriate of Potash		Actual Potash
80 per cent.	contains	50.5 per cent.
95 per cent.	contains	60.0 per cent.
98 per cent.	contains	61.9 per cent.

For fertilizing purposes, all muriate of potash is sold on the basis of 80 per cent. pure muriate of potash, corresponding to 50.5 per cent. actual potash. Muriate of potash serves as a basis for the manufacture of many other potash salts, such as nitrates, chlorates, etc.

There are many by-products in the manufacture of muriate of potash, notably magnesium chlorid and sulfate of soda, which latter, owing to its purity and freedom from acid salts, is largely used in the manufacture of the cheaper grades of glass. From the residuum of the first solution of carnallit, treated with cold water, kieserit (sulfate of magnesia) settles out in fine crystalline particles, and is moulded into blocks. Large quan-

tities of bromine and iron bromide are obtained at the end of the process. Some of the potash factories also prepare calcined magnesia, hydrate of magnesia, calcium chlorid, carbonate of potash, carbonate of potash-magnesia, etc.

In order to obtain the complete extraction of potash, the processes of manufacture are complex, and solutions and salts require repeated handling. It naturally follows that the separation of commercially pure salts, from solutions of other salts, is an expensive process, and that it is only by the most painstaking care and full utilization of every possible by-product, that potash salts can be produced and sold at the present low prices.

Sulfate of potash is manufactured in less quantities than muriate, owing to smaller demand for it in the market and there are several processes of manufacture. The commercial salt sulfate of potash-magnesia, containing 48 per cent. of sulfate of potash, was formerly manufactured from kainit, but at present most of the works use muriate of potash and kieserit. A mixture of these minerals in a concentrated solution precipitates the sulfate of potash-magnesia. In the manufacture of sulfate of potash a solution of sulfate of potash-magnesia and a given quantity of muriate of potash are boiled together, whereupon the less soluble sulfate of potash separates and falls as a precipitate. The commercial sulfate of potash varies from 90 to 96 per cent. pure, equivalent to 47 to 52.7 per cent. actual potash.

The tables on pages 30 and 31 give the average analyses of the more important potash salts. The figures show the

pounds of various substances in 100 pounds of the different salts, but only the percentage of potash is guaranteed.

The numerous by-products obtained in refining the crude potash salts are utilized in many ways and for various purposes. Some of them contain 20 to 30 per cent. actual potash, but in most cases in such combination as not to pay for necessarily expensive extraction. Because of this comparatively large content of potash, however, they are dried, calcined, pulverized, and mixed with crude salts, or other poorer forms of potash, to increase the potash content of these salts and give them added value for agricultural purposes.

Besides the agricultural, soil-restoring, plant-feeding use of potash salts, large quantities are consumed by the chemical industry in Germany, the United States and other countries, in the manufacture of carbonate of potash, caustic potash, nitrate of potash, chlorate of potash, chromate and bichromate of potash, alum, cyanide of potash, bromide of potash, permanganate of potash, yellow prussiate, and other compounds. The many sided technical and industrial activity of the age, in almost every trade, must have potash in one form or another. Doctors, photographers, painters, dyers, cleaners, bleachers, weavers, soapmakers and electricians use it, while the modern rapid, cheap production of artificial cold, of preservatives, fireworks, gunpowder, matches, paper, glass and aniline dyes, and the extraction of gold from its ores are impossible without it. While applications are thus without number, it is of greatest importance in agriculture in supplying plant food.

CRYSTALLIZING VATS

Composition of Potash Salts

Crude Salts (Natural Products).

	Kainit	Carnallit	Hardsalt
Actual Potash (K_2O)	12.8%	9.8%	16.4%
Minimum Guarantee (K_2O) ..	12.0%	9.0%	16.0%

Concentrated Salts (Manufactured Products)

	Sulfates (Nearly free from Chlorids)			Salts containing Chlorids			
	Sulfate of Potash		Sulfate of Potash-Magnesia	Muriate of Potash			Potash Manure Salts Min. 20%
	90%	96%		Min. 98%	Min. 95%	80/85%	
Actual Potash (K_2O) ...	50.0%	52.7%	27.7%	61.9%	60.0%	52.7%	21.0%
Minimum Guarantee (K_2O) ...	47.0%	....	25.0%	....	....	48.0%	20.0%

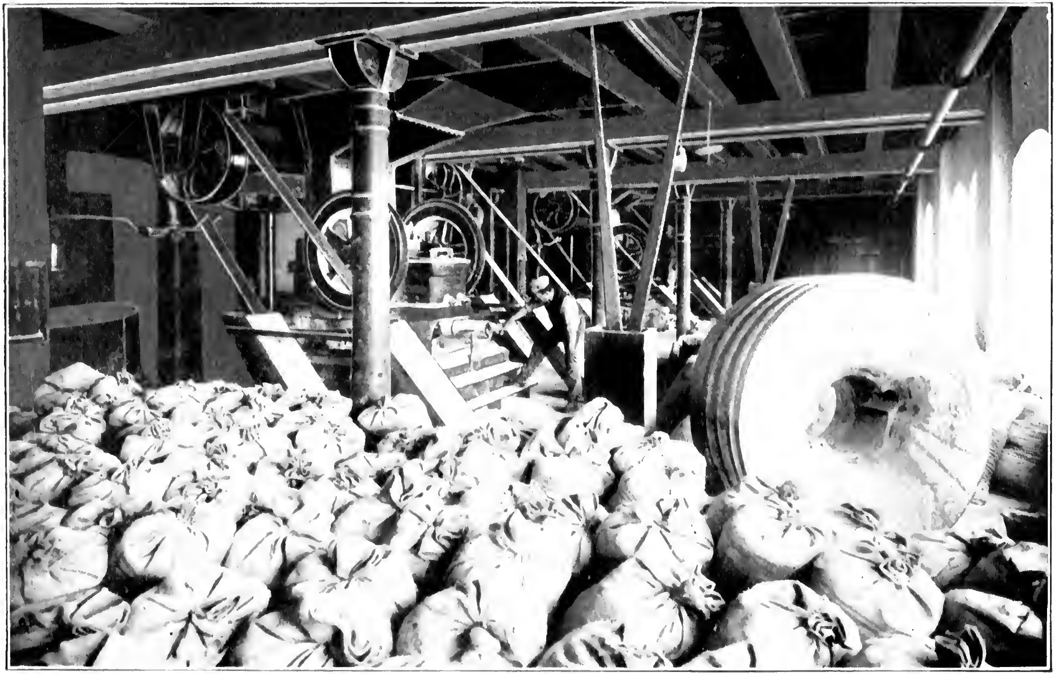
Sulfates (Nearly Free From Chlorids).

	Sulfate of Potash		Sulfate of Potash-Magnesia (Double Manure Salt)
	90%	96%	
Actual Potash (K_2O)	50.0%	52.7%	27.7%
Sulfate of Potash (K_2SO_4)	90.6%	97.2%	49.0%
Muriate of Potash (KCl)	1.6%	0.3%	0.9%
Sulfate of Magnesia ($MgSO_4$)	2.7%	0.7%	28.4%
Chlorid of Magnesia ($MgCl_2$)......	1.0%	0.4%	0.5%
Chlorid of Sodium (NaCl).........	1.2%	0.2%	2.2%
Sulfate of Lime ($CaSO_4$)	0.4%	0.3%	....
Insoluble Substances	0.3%	0.2%	7.0-14.5%
Water	2.2%	0.7%	4.5-12.0%
Minimum Guarantee Actual Potash (K_2O)	47.0%	......	25.0%

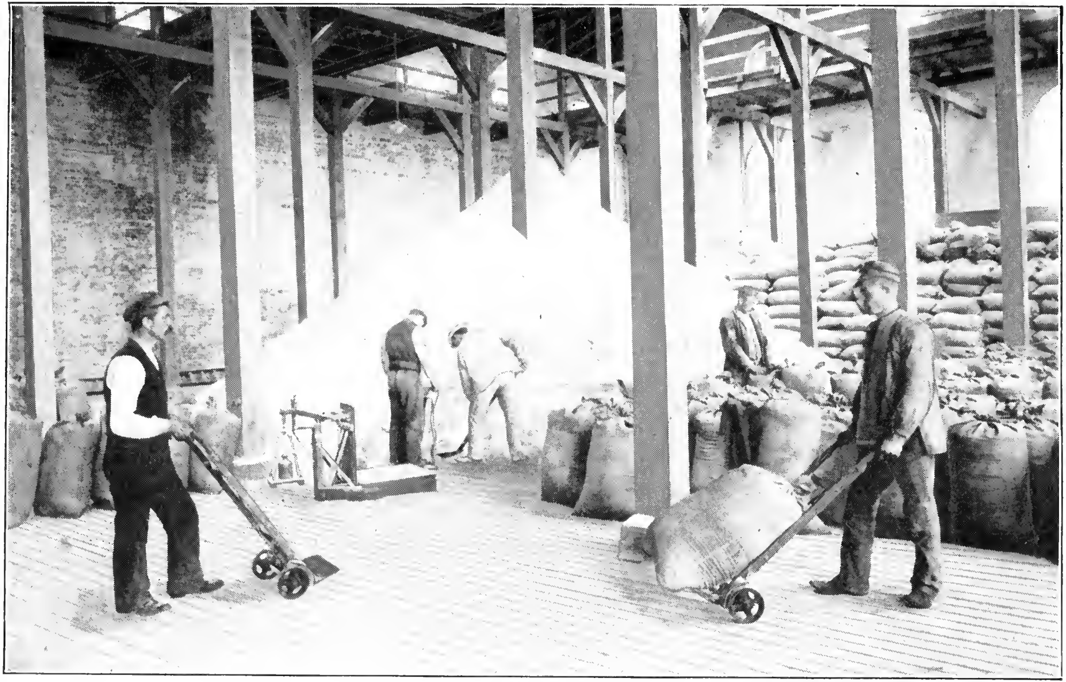
SALTS CONTAINING CHLORIDS

	Muriate of Potash			Potash Manure Salts
	Min. 98%	Min. 95%	80/85%	Min. 20%
Actual Potash	61.9%	60.0%	52.7%	21.0%
Muriate of Potash	98.0%	95.0%	83.5%	31.6%
Sulfate of Potash	....	....	....	2.0%
Sulfate of Magnesia	0.2%	0.2%	0.4%	10.6%
Chlorid of Magnesia	0.2%	0.2%	0.3%	5.3%
Chlorid of Sodium	1.0%	3.8%	14.5%	40.2%
Sulfate of Lime	....	....	....	2.1%
Insoluble Substances	0.2%	0.2%	0.2%	4.0%
Water	0.4%	0.6%	1.1%	4.2%
Minimum Guarantee Actual Potash (K_2O)			48.0%	20.0%

NOTE.—If potash salts are exposed to moist conditions they absorb water, and this occurs sometimes during transportation. In such case the salts are diluted, they show a somewhat lower percentage of potash which may even fall below guarantee. There is no real loss, however, because the weight of the bags increases by the absorption of moisture and the amount of potash in them remains unchanged. On this account in making State Registrations to comply with fertilizer laws the 80% muriate of potash is only guaranteed to contain 48% actual potash and 90% sulfate of potash is only guaranteed to contain 47% actual potash. In sulfate of potash magnesia a minimum of 48% sulfate of potash and 25% sulfate of magnesia is guaranteed, also a maximum content of 2.5% chlorin. The amounts of other ingredients shown are those usually present, but these amounts are variable and are not guaranteed in any of the salts. The color of the crude salts or of the manufactured products has no relation to the purity or quality of these products. The color may vary widely within the limits of the same mine.



MILLS FOR GRINDING CRUDE POTASH SALTS



BAGGING POTASH SALTS

Commercial Statement

FOR sixty years the world's demand for potash has grown rapidly until today it is over eleven million tons per year, and the German Potash industry alone enables this demand to be satisfied.

Previous to the discovery of the German deposits, potash, as used in the arts, was derived chiefly, as its name implies, from the leaching of wood ashes. The supply to be had from wood ashes is limited and there are a few minor sources of supply such as potash from kelp, from woolwashings, from beet sugar residues, and others, all of which, however, sink into insignificance when compared with the quantities produced by the German mines.

In 1880 the various mines producing potash were combined under a central office. The organization now includes about 115 mines:

This combination has about 510 executive officers, including 230 representatives in foreign countries, while the mines themselves employ in round numbers, 2,200 officers and 35,000 laborers, and use 1,600 boilers and 2,200 steam engines with 220,000 horse power. Each of the works has its own railroad track, connecting with the main line, and, in some cases, this reaches a length of about 7½ miles, and most of the works have their own locomotives and railroad cars.

The average daily output is 3,670 carloads of ten tons, but in the best seasons, of the year, which are the spring and fall, it reaches as high as 5,000 carloads of ten tons each. The following table gives the production of crude salts, from the commencement of mining to the close of 1911:

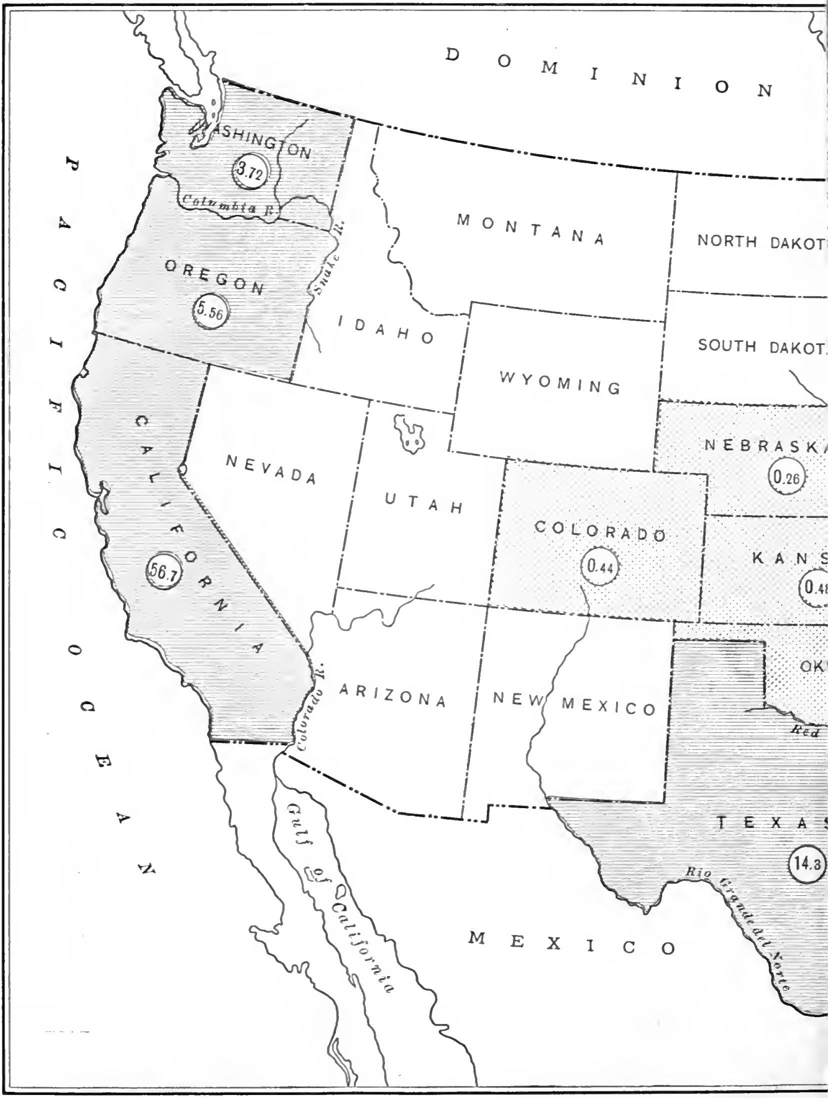
Production of Crude Salts

(Metric Tons of 2,204 lbs.)

Year	Carnallit	Rock Kieserit	Kainit and Hardsalt	Sylvinit	Total
1861	2,293	....	......	......	2,293
1862	19,727	20	......	......	19,747
1863	58,303	68	......	......	58,371
1864	115,408	89	......	......	115,497
1865	87,671	75	1,314	......	89,060
1866	135,554	413	5,808	......	141,775
1867	141,604	1,143	8,976	......	151,723
1868	167,337	1,418	10,772	......	179,527
1869	211,884	226	16,857	......	228,967
1870	268,226	71	20,301	......	288,598
1871	335,945	47	36,582	......	372,574
1872	468,537	22	18,067	......	486,626
1873	441,079	7	6,101	......	447,187
1874	414,961	16	9,753	......	424,730
1875	498,737	5	24,124	......	522,866
1876	563,669	145	17,938	......	581,752
1877	771,819	151	35,477	......	807,448
1878	735,750	520	34,004	......	770,274
1879	610,427	761	50,206	......	661,394
1880	528,212	893	139,491	......	668,596
1881	744,726	2,082	158,330	......	905,138
1882	1,059,300	4,658	148,477	......	1,212,435
1883	950,203	11,790	228,817	......	1,190,811
1884	739,959	12,389	217,107	......	969,455
1885	644,710	11,970	272,369	......	929,049
1886	698,229	13,918	247,327	......	959,474
1887	840,207	14,186	237,629	......	1,092,022
1888	849,602	10,754	375,574	2,220	1,238,150
1889	798,721	9,354	362,611	28,329	1,199,015
1890	838,526	6,951	401,871	31,917	1,279,265
1891	818,862	5,816	512,494	32,661	1,369,833
1892	736,751	5,782	585,775	32,669	1,360,977
1893	794,660	4,807	689,994	49,140	1,538,601
1894	851,338	3,865	729,301	63,495	1,647,999
1895	782,944	3,012	669,532	76,097	1,531,585
1896	856,223	2,841	833,025	90,390	1,782,479
1897	851,272	2,619	1,012,186	84,105	1,950,182
1898	990,998	2,444	1,120,616	94,270	2,208,328
1899	1,317,947	2,066	1,063,195	100,653	2,483,861
1900	1,697,803	2,047	1,189,394	147,791	3,037,035
1901	1,860,189	2,335	1,432,136	190,034	3,484,694
1902	1,705,665	1,821	1,354,528	188,821	3,250,835
1903	1,844,036	1,553	1,582,867	196,140	3,624,596
1904	1,911,166	1,055	1,906,823	234,455	4,053,499
1905	2,239,710	2,731	2,405,536	230,622	4,878,599
1906	2,263,197	9,190	2,754,021	284,943	5,311,351
1907	2,534,789	10,359	2,788,973	304,143	5,638,264
1908	2,768,794	18,473	2,921,712	305,282	6,014,261
1909	3,280,726	7,388	3,268,290	344,749	6,901,153
1910	3,582,885		4,577,893		8,160,778
1911	4,441,664		5,264,843		9,706,507

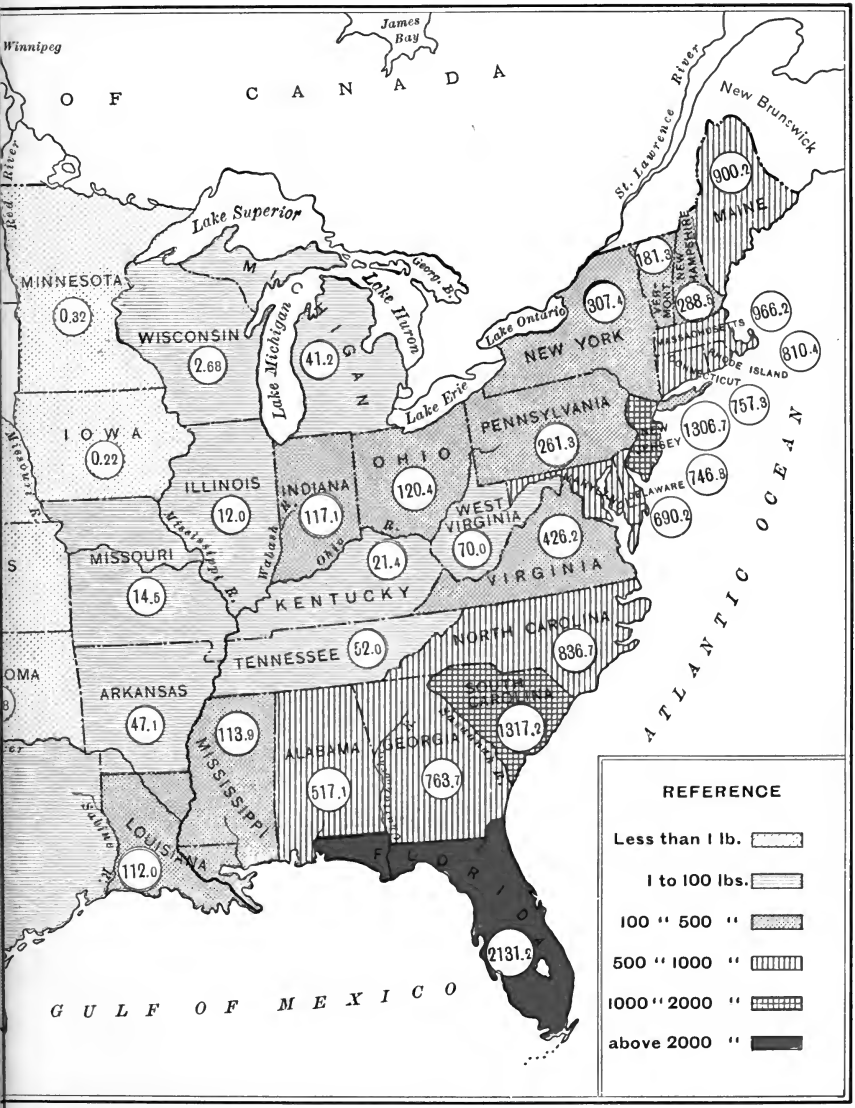
Potash Consumption in

CALCULATED IN POUNDS PURE POTA



he United States in 1910

PER 100 ACRES OF CULTIVATED LAND



These salts were either sold directly from the mines, for agricultural purposes, or manufactured into more concentrated potash products for use in agriculture, or in the arts and other manufactures. The table on page 40 shows the use made of the various salts, from 1880 to the close of 1911. The greater part of the crude salts, manufactured into concentrated products was converted into muriate of potash. The table on opposite page gives, in metric tons of 2,204 pounds each, full detailed data as to the various concentrated salts produced from 1878 to the close of 1911.

The chart on page 42, illustrates the consumption in the United States of pure potash contained in the various potash salts for the years 1895 to the end of 1911 and shows the progress of potash consumption made during that time.

The table on pages 44 and 45, shows the total quantities of the various potash salts and of pure potash contained in them that were imported into the United States during various years. It is of interest to emphasize the fact that the quantities imported for agricultural purposes in 1911 were 1,002,326 tons and for the industries 22,828 tons and for both agriculture and industries 1,025,154 tons. The transportation of this enormous weight would require 256 steamers of 4,000 tons each, and is represented in the illustration on page 51.

The greater part of the total potash production as has been before stated, is used for agricultural purposes,—that is, as food for plants, as the following table, giving

Production of Concentrated Potash Salts

(In Metric Tons.)

Year	Muriate of Potash 80 Per Cent.	Sulfate of Potash 90 Per Cent.	Sulfate of Potash Magnesia Calcined. 48 Per Cent.	Potash Manure Salt	Sulfate of Potash Magnesia Crystallized 40 Per Cent.	Kieserit in Blocks	Kieserit Ground and Calcined
1878	110,761	.....	5,500	9,400	.....	.....	....
1879	92,402	.....	6,000	8,800	.....	.....	....
1880	96,832	.....	7,000	9,500	.....	.....	....
1881	115,266	.....	9,000	10,100	.....	.....	....
1882	152,961	5,000	12,000	14,000	.....	.....	....
1883	136,000	.....	10,000	11,800	.....	17,500	....
1884	106,330	3,000	8,000	9,500	400	17,800	....
1885	104,500	4,000	9,000	8,400	450	18,500	....
1886	110,200	3,639	10,111	8,161	472	19,500	....
1887	130,000	10,528	6,285	8,163	500	24,018	....
1888	132,000	10,916	11,380	13,918	522	28,325	....
1889	131,593	7,321	9,215	17,285	671	31,824	....
1890	134,760	13,839	10,830	17,620	907	32,005	....
1891	143,487	18,981	11,400	16,045	1,053	28,559	....
1892	121,029	15,466	11,842	16,895	708	23,855	11
1893	132,528	16,361	12,643	17,344	739	24,386	105
1894	147,936	15,242	12,718	19,727	1,780	26,440	216
1895	145,027	13,403	8,249	19,724	898	25,115	142
1896	155,805	13,889	4,622	19,253	1,051	24,987	211
1897	158,863	15,403	7,415	23,042	922	25,669	214
1898	174,380	17,781	10,535	24,284	914	19,934	728
1899	180,672	24,656	8,459	70,926	579	28,216	260
1900	206,471	31,255	12,150	129,908	932	28,507	358
1901	211,421	28,196	11,750	147,170	936	26,726	361
1902	191,039	30,202	16,834	139,329	600	26,808	767
1903	206,347	38,407	22,296	161,786	778	23,509	548
1904	235,298	39,146	27,672	196,860	775	26,471	463
1905	254,711	42,420	30,589	215,407	718	35,002	600
1906	279,320	51,181	37,097	278,285	834	29,411	632
1907	291,248	56,253	31,503	286,261	788	26,521	457
1908	288,524	54,751	33,756	313,220	665	25,532	668
1909	327,632	70,577	37,614	381,479	507	27,104	546
1910	434,243	93,208	41,529	524,874	168	29,854	754
1911	443,357	110,123	49,014	645,724	144	30,177	715

Use Made of Crude Potash Salts

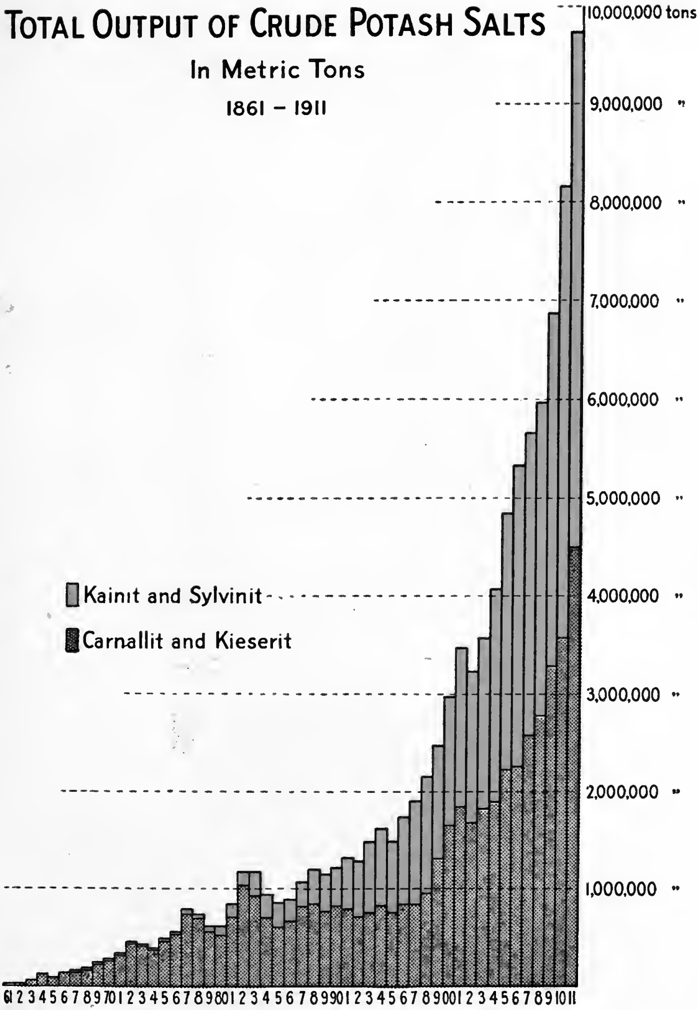
(Metric Tons of 2,204 lbs.)

Year	Carnallit and Rock Kieserit.				Kainit and Sylvinit (Incl. Hardsalt).			
	For Agricultural Purposes		For Manufacturing Concentrated Salts	Total	For Agricultural Purposes		For Manufacturing Concentrated Salts	Total
	Germany	All Other Countries			Germany	All Other Countries		
1880	4,137		524,968	529,105	23,769	103,749	11,973	139,491
1881	6,902		739,905	746,807	20,372	119,491	18,467	158,330
1882	10,249		1,053,710	1,063,959	30,413	95,263	22,800	148,477
1883	17,434		944,560	961,994	48,138	153,200	27,479	228,817
1884	18,654		733,694	752,348	48,643	109,656	58,807	217,106
1885	18,989		637,691	656,680	50,870	143,518	77,981	272,369
1886	22,729		689,418	712,147	65,835	105,050	76,441	247,326
1887	30,892		823,500	854,392	84,493	89,293	63,842	237,628
1888	31,776		828,580	860,356	105,237	142,171	130,386	377,794
1889	35,579	382	772,115	808,075	150,342	113,109	127,489	390,940
1890	32,091	373	813,013	845,477	178,031	126,984	128,772	433,787
1891	35,770	551	788,357	824,678	240,001	173,508	131,646	545,155
1892	42,456	1,253	698,824	742,533	366,661	131,912	119,871	618,444
1893	55,824	3,483	735,874	795,181	428,891	184,358	125,884	739,134
1894	57,399	4,117	793,687	855,203	466,208	200,240	126,348	792,796
1895	46,280	3,836	735,830	785,946	436,922	190,732	117,975	745,629
1896	52,693	3,964	802,407	859,064	556,516	245,060	121,839	923,415
1897	54,375	5,157	794,359	853,891	667,342	295,765	133,183	1,096,290
1898	56,604	7,189	929,649	993,442	721,535	334,111	159,240	1,214,886
1899	54,538	4,611	1,260,869	1,320,018	717,097	314,869	131,882	1,163,848
1900	51,262	2,869	1,645,719	1,699,850	723,654	375,007	238,524	1,337,185
1901	73,025	7,382	1,782,117	1,862,524	857,577	494,220	270,372	1,622,169
1902	89,127	7,933	1,610,425	1,707,485	845,753	451,619	245,977	1,543,349
1903	73,092	3,472	1,769,025	1,845,589	978,667	486,853	313,488	1,779,008
1904	75,679	4,853	1,831,689	1,912,221	1,202,586	544,091	394,601	2,141,278
1905	69,107	2,739	2,170,595	2,242,441	1,267,989	742,544	625,624	2,636,157
1906	65,173	2,105	2,205,109	2,272,387	1,407,553	818,540	812,872	3,038,965
1907	62,278	2,407	2,480,463	2,545,148	1,456,731	750,191	886,194	3,093,116
1908	64,675	2,973	2,719,619	2,787,267	1,613,484	774,495	839,016	3,226,995
1909	66,781	2,761	3,218,571	3,288,113	1,744,522	877,310	991,208	3,613,040
1910	70,268	3,301	3,509,317	3,582,886	1,884,237	1,167,021	1,526,636	4,577,894
1911	71,439	862	4,369,363	4,441,664	2,131,706	1,080,205	2,052,932	5,264,843

TOTAL OUTPUT OF CRUDE POTASH SALTS

In Metric Tons

1861 – 1911

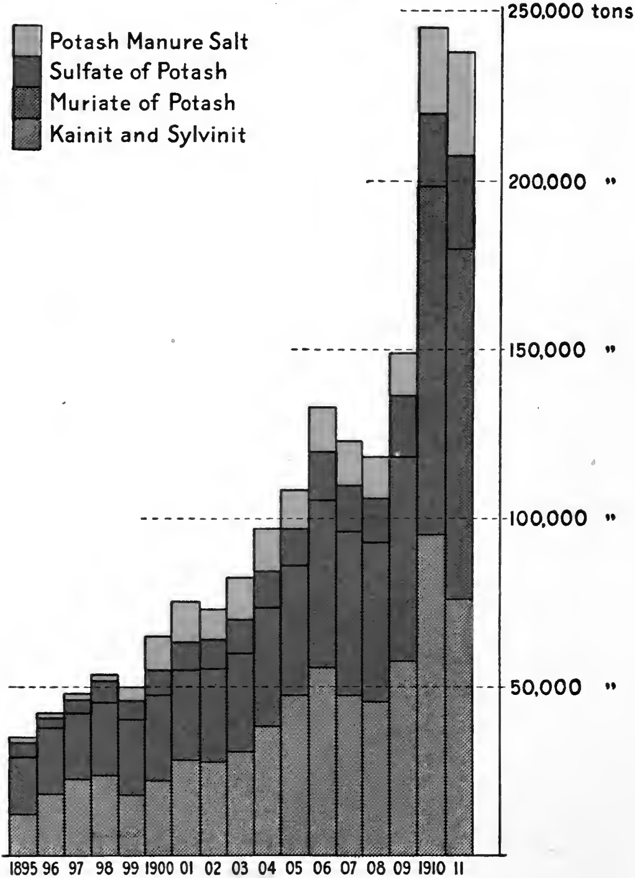


Consumption Of Potash Salts in United States

For Agricultural Purposes

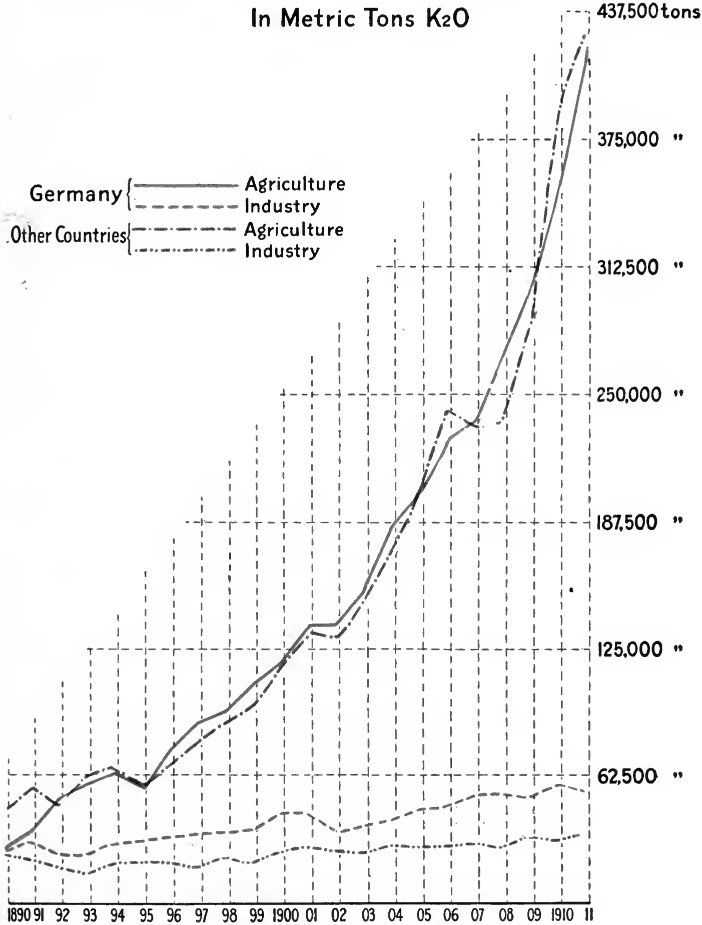
1895 to 1911

In Metric Tons K_2O



A Comparison of Amounts of Actual Potash used in Agriculture and the Industries

In Metric Tons K_2O



Consumption of Potash Salts of All Kinds Agriculture and

(In Metric Tons.)

AGRICULTURE.

Year	Kainit		Sylvinit		Muriate		Sulfate	
	Salt	K_2O	Salt	K_2O	Salt	K_2O	Salt	K_2O
1895	76.430	9,477	16.066	2.988	33.523	16,929	5.181	2,518
1900	172,948	21.446	3,445	630	50,789	25,679	11,426	5,561
1901	225,139	27.917	2,506	458	51,973	26.277	12,756	6.208
1902	220,642	27,360	2,135	391	54,432	27,521	12.780	6.220
1903	242,183	30,031	1.420	250	57,945	29,297	17.801	8,664
1904	302.760	37,542	3,087	576	69,540	35,159	14,539	7.076
1905	385.794	47.838	2,998	554	75.614	38.230	16.870	8,210
1906	421,633	52.283	18,689	2,990	98,471	49,787	21,598	10,512
1907	367,714	45,597	12.627	2.022	95,544	48.309	22,225	10,818
1908	347,392	43,077	13,813	2,213	92,540	46.790	21,242	10,340
1909	404.611	50,172	45,621	7,332	119,006	60,172	30,134	14,668
1910	592,274	73,442	138,203	22,112	202,857	102,569	36,961	17,990
1911	502,492	62,310	85,083	13,613	204,390	103,344	47,937	23,333

INDUSTRIES.

Year	Kainit		Sylvinit		Muriate		Sulfate	
	Salt	K_2O	Salt	K_2O	Salt	K_2O	Salt	K_2O
1895	......	......	......	......	8,432	4,258	991	482
1900	......	......	......	......	13,751	6,944	947	460
1901	......	......	......	......	14,520	7.333	1.000	487
1902	......	......	......	......	14.751	7.449	1.050	510
1903	......	......	......	......	13.328	6.738	965	470
1904	......	......	......	......	18,448	9.327	1.397	680
1905	......	......	......	......	14,472	7,317	1,426	694
1906	......	......	......	......	17,661	8,929	805	392
1907	......	......	......	......	16.293	8.238	710	346
1908	......	......	......	......	11,006	5.565	772	376
1909	......	......	......	......	16,671	8.429	485	236
1910	......	......	......	......	16,869	8,529	769	374
1911	......	......	......	......	22,361	11,306	467	227

and of Pure Potash in the United States in in the Industries

Sulfate of Potash Magnesia		Manure Salt, 30% 28% before 1899		Manure Salt 20%		Total	
Salt	K_2O	Salt	K_2O	Salt	K_2O	Salt	K_2O
7,371	1,909	305	85			138,876	33,907
7,125	1,850	4,115	1,234	43,756	8,751	293,605	65,152
7,366	1,912	3,962	1,189	53,016	10,603	356,718	74,566
9,399	2,440	3,962	1,189	38,096	7,619	341,446	72,739
9,207	2,390	4,064	1,219	55,591	11,118	388,211	82,970
12,821	3,328	4,064	1,219	58,176	11,635	464,987	96,536
11,562	3,002	10,160	3,048	41,046	8,209	544,044	109,093
13,196	3,426	10,160	3,048	50,664	10,133	634,410	132,178
9,854	2,558	10,160	3,048	50,092	10,018	568,217	122,370
13,511	3,507	10,160	3,048	42,571	8,514	541,229	117,489
12,681	3,292	8,839	2,652	50,953	10,190	671,845	148,479
12,867	3,340	12,963	3,897	106,493	21,319	1,103,197	244,911
		40% 579	240				
15,991	4,151	12,565	3,927	133,867	26,773	1,002,326	237,453

Sulfate of Potash Magnesia		Manure Salt, 30% 28% before 1899		Manure Salt 20%		Total	
Salt	K_2O	Salt	K_2O	Salt	K_2O	Salt	K_2O
......	.....	......	......	......	......	9,423	4,739
......	.....	......	......	......	......	14,698	7,405
......	.....	......	......	......	......	15,520	7,819
......	.....	......	......	......	......	15,801	7,960
......	.....	......	......	......	......	14,293	7,208
......	.....	......	......	......	......	19,846	10,008
......	.....	......	......	......	......	15,899	8,011
......	.....	......	......	......	......	18,466	9,321
......	.....	......	......	......	......	17,003	8,584
......	.....	......	......	......	......	11,778	5,941
......	.....	......	......	......	......	17,156	8,665
......	.....	......	......	......	......	17,638	8,904
......	.....	......	......	......	......	22,828	11,534

the total amount of actual potash consumed in agriculture and in the arts during the years 1890, 1900 an 1911 will show:

	1890 TONS.	1900 TONS.	1911 TONS.
Potash used for agricultural purposes,	71,455	232,820	848,401
Potash used for industrial purposes,	50,846	70,790	91,526

The diagram on page 43, is designed to show graphically the relative consumption of actual potash (K_2O) in agriculture and in the industries during the years 1890 to 1911.

The consumption of potash in different countries is best shown by the table on page 48, giving amounts of "actual potash" used in each case, on the basis of a ton of 2,204 pounds.

The colored chart on page 52, illustrates the consumption of potash in different countries during the years 1900 and 1911. The table on page 49, points out the consumption of actual potash in pounds per 100 acres of cultivated land. This is shown graphically in the diagram on page 50. Incidentally but strikingly it indicates the actual progress in agricultural development of the different countries.

The relatively small consumption by the United States according to this table is scarcely a just comparison. Much of the cultivated land in this country has, in the past, been "new" or "virgin" soil, to which no regular applications of plant food have been supplied.

The consumption of fertilizers in the United States during the year 1910 was (in round figures) 6,100,000 tons (2,000 lbs. each), the amount of potash consumed during that year was approximately 250,000 tons. The table

following shows the amounts of potash consumed in each state, also the amount of fertilizer used, the average per cent of potash in the fertilizers, number of acres of land in cultivation and pounds of potash consumed per 100 acres of cultivated land in each state. The map on page 36-37, shows graphically the amount of potash used in each state per 100 acres of cultivated land.

Potash and Fertilizer Statistics in the United States for 1910

(Tons in this table are short tons of 2,000 lbs.)

State	Potash Consumption Tons	Average Potash Content in Fertilizers Per Cent.	Fertilizer Consumption Tons	Cultivated Lands Acres	Potash Consumed on Cultivated Lands, Pounds per 100 Acres
Georgia	44,650	3.51	1,134,000	10,424,400	763.7
S. Carolina	42,706	3.63	1,048,806	5,780,750	1,317.2
N. Carolina	28,909	4.09	630,095	6.160,000	836.7
Alabama	22,475	3.32	603,483	7,749,600	517.1
New York	17,891	5.65	282,280	10,377,500	307.4
Virginia	16,500	4.02	365,897	6,902,700	426.2
Florida	15,086	7.79	172,641	1,262,100	2,131.2
Pennsylvania	12,990	3.86	300,000	8,862,000	261.3
New Jersey	9,234	6.86	120,000	1,260,000	1,306.7
Maryland	9,086	3.60	225,000	2,347,100	690.2
Ohio	9,082	4.64	174,508	13,447,000	120.4
Maine	8,334	6.40	116,085	1,650,600	900.2
Indiana	7,768	4.56	151,865	11,832,100	117.1
Massachusetts	4,408	6.14	64,000	813,400	966.2
Mississippi	4,007	2.69	132,776	6,271,300	113.9
Louisiana	2,983	2.92	91,085	4,751,200	111.9
Connecticut	2,925	6.52	40,000	688,800	757.3
California	2,533	4.91	46,000	7,966,000	56.7
Tennessee	2,222	3.38	58,612	7,612,500	52.0
Delaware	2,088	5.03	37,000	498,400	746.8
Michigan	2,073	4.62	40,000	8,973,300	41.2
Texas	1,854	3.12	52,985	23,052,000	14.3
W. Virginia	1,506	4.13	32,500	3,837,400	70.0
Arkansas	1,490	3.32	40.000	5,643,400	47.1
Missouri	1,399	3.95	31,585	17,169,600	14.5
Illinois	1,322	3.93	30,000	19,603,500	12.0
Kentucky	1,204	4.05	26,500	10,033,800	21.4
Vermont	1,162	5.18	20,000	1,143,100	181.3
New Hampshire	1,050	5.20	18.000	648,900	288.5
Rhode Island	566	5.61	9,000	124,600	810.4
Wisconsin	125	5.58	2,000	8,317,400	2.68
Oregon	93	6.90	1,210	2,977,100	5.56
Washington	93	6.90	1,210	4,447,800	3.72
Kansas	57	4.17	1,210	20,900,600	.48
Oklahoma	34	3.00	1,000	12,247,200	.48
Iowa	25	4.50	500	20,626,900	.22
Minnesota	25	4.50	500	13,726,300	.32
Nebraska	25	4.50	500	17,049,200	.26
Colorado	8	4.50	150	3,003,700	.44

Consumption of Potash in Agriculture in the Most Important Countries

Total consumption in metric tons of pure potash (K_2O).

Country	1900	1901	1902	1903	1904	1905
Germany	117,211	137,314	137,277	153,631	187,919	202,109
United States	65,152	75,053	72,739	82,970	96,536	109,091
Belgium	3,607	6,304	3,266	4,618	5,770	9,341
Holland	7,106	9,370	8,605	10,250	11,452	17,329
France	8,229	6,285	4,938	9,324	9,285	11,204
England	4,020	4,212	4,683	5,813	6,390	8,745
Scotland	3,370	3,752	4,653	4,370	4,846	5,630
Ireland	600	705	570	1,035	1,228	1,626
Austria	2,281	3,291	3,177	3,650	4,885	5,778
Hungary	108	245	318	356	549	470
Switzerland	1,026	1,691	728	1,426	1,447	1,327
Italy	1,379	1,306	1,447	1,522	1,925	2,308
Russia	1,597	2,079	2,486	1,916	2,176	2,539
Spain	2,428	2,498	1,552	2,841	3,078	3,185
Portugal	42	54	66	111	208	259
Sweden	8,197	9,303	11,011	9,096	11,222	14,391
Norway	286	320	432	526	691	975
Denmark	1,692	2,499	2,415	2,391	1,889	3,880
Finland	382	512	880	353	250	429
Asia	497	233	444	694	1,015	1,092
Africa	553	677	395	431	462	496
Central & So. America	515	520	658	514	354	487
Australia	420	344	179	608	533	1.047

Country	1906	1907	1908	1909	1910	1911
Germany	228.485	240,779	272,989	305,960	359,336	422,341
United States	132,249	122,370	117,489	148,479	244,911	237,453
Belgium	8,376	7,240	9,206	9,485	8,987	9,101
Holland	19,452	18,893	22,212	22,938	29,398	34,375
France	15,465	12,380	15,345	17,645	22,850	26,468
England	8,721	9,718	8,572	9,547	9,935	11,533
Scotland	5,792	5,905	5,477	5,335	5,897	6,564
Ireland	2,111	1,989	1,967	2.269	2,801	3,120
Austria	6,841	7,759	9,518	13,327	11,814	15,065
Hungary	667	568	760	1,202	1,343	2,744
Switzerland	1,541	1,744	2,800	3,075	2,777	2,678
Italy	2,819	3,449	3,251	4,129	5,601	6,061
Russia	2,525	3,594	5,567	8,838	14,548	17,079
Spain	4,133	4,534	4,403	5,188	7,348	9,845
Portugal	348	578	329	543	791	1,131
Sweden	16.434	17,880	14,852	15,672	16,627	17,452
Norway	1,273	1,586	1,632	1,695	1,761	2,283
Denmark	4,469	3,658	3,807	3,474	4,367	5,632
Finland	667	1,015	692	800	982	1,326
Asia	1,310	1,905	1,629	2,157	3,210	4,670
Africa	741	579	703	962	1,643	2,293
Central & So. America	196	1,143	1,580	1,826	3,015	3,905
Australia	1,137	1,211	1,333	1,454	1,826	1,848

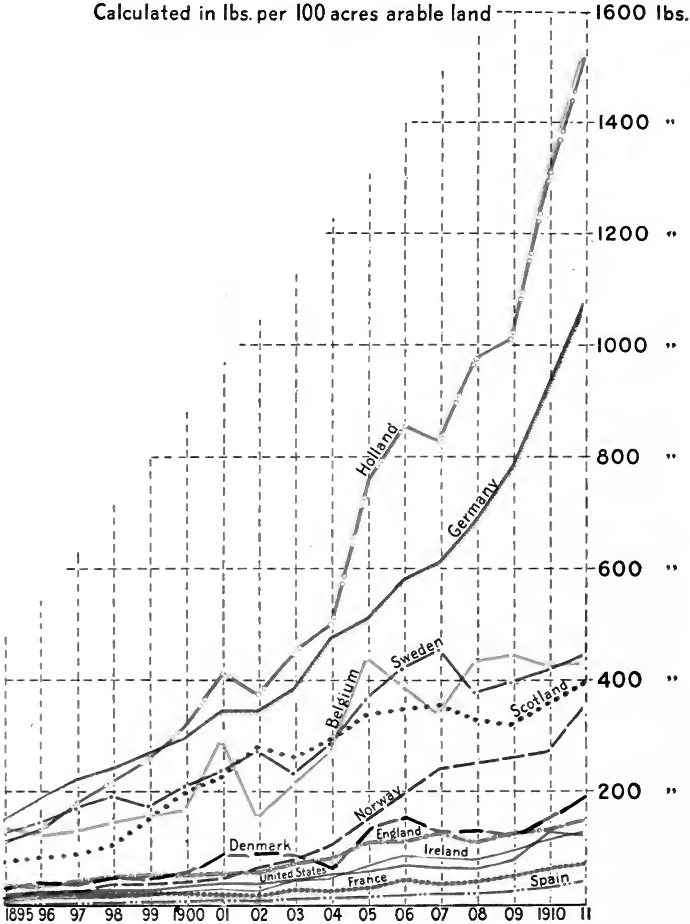
Consumption of Pure Potash (K_2O) for Agricultural Purposes in Different Countries

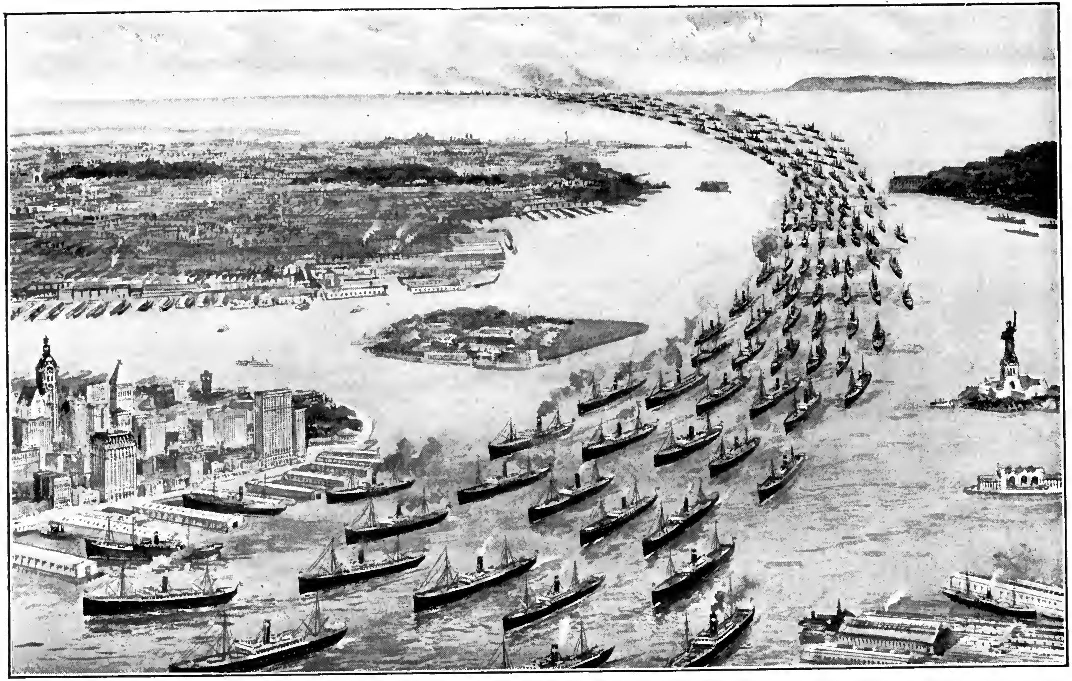
(Calculated in lbs. per 100 acres arable land.)

Country	Arable Land including Pastures in Acres	1900	1901	1902	1903	1904	1905
Germany	86,625,399	298.3	349.4	349.3	391.0	478.2	514.2
United States	414,491,441	34.6	39.7	38.6	44.2	51.4	58.0
Belgium	4,659,506	170.6	298.2	154.5	218.5	273.0	441.9
Holland	5,012,379	312.5	412.0	378.4	450.7	503.6	762.0
France	81,099,031	22.4	17.0	13.4	25.3	25.2	30.4
England	16,916,409	52.4	54.9	61.0	75.7	83.2	113.9
Scotland	3,641,413	204.0	227.1	281.7	264.5	293.4	340.8
Ireland	5,322,749	24.8	29.2	23.6	42.8	50.8	67.3
Austria	35,362,182	14.1	20.5	19.9	22.7	30.4	36.0
Hungary	42,863,206	0.6	1.2	1.6	1.9	2.8	2.4
Switzerland ..	5,524,391	40.9	67.5	29.1	56.9	57.7	53.0
Italy	39,895,910	7.6	7.2	8.0	8.4	10.6	12.8
Russia	318,621,904	1.1	1.4	1.7	1.3	1.5	1.8
Spain	54,405,467	9.8	10.1	6.3	11.5	12.5	12.9
Portugal	11,329,499	0.8	1.1	1.3	2.1	4.0	5.1
Sweden	8,622,409	209.5	237.8	281.5	232.5	286.9	367.9
Norway	1,412,975	44.7	49.9	67.3	82.1	107.8	152.2
Denmark ...	6,305,259	59.1	87.4	84.4	83.6	66.0	135.7
Finland	2,755,277	30.6	40.9	69.8	28.2	20.0	34.3

Country	Arable Land including Pastures in Acres	1906	1907	1908	1909	1910	1911
Germany	86,625,399	581.4	612.7	684.6	778.5	914.4	1,074.7
United States	414,491,441	70.3	64.8	62.0	78.9	130.2	126.3
Belgium	4,659,506	396.2	342.4	435.5	448.7	425.1	430.5
Holland	5,012,379	855.4	830.8	976.7	1,008.8	1,292.8	1,511.7
France	81,099,031	42.1	33.6	41.7	48.0	62.1	71.9
England	16,916,409	113.6	126.7	111.7	124.4	129.4	150.3
Scotland	3,641,413	350.6	357.4	331.6	322.9	357.0	397.4
Ireland	5,322,749	87.4	82.3	81.4	93.9	116.0	129.2
Austria	35,362,182	42.6	48.3	59.3	83.0	73.7	93.9
Hungary	42,863,206	3.4	2.9	3.9	6.2	6.9	14.1
Switzerland .	5,524,391	61.5	69.6	111.8	122.6	110.8	106.9
Italy	39,895,910	15.6	19.1	17.9	22.8	31.0	33.5
Russia	318,621,904	1.8	2.5	3.8	6.2	10.1	11.8
Spain	54,405,467	16.8	18.4	17.8	21.1	29.8	39.9
Portugal	11,329,499	6.8	11.2	6.4	10.5	15.4	22.0
Sweden	8,622,409	420.1	457.1	379.6	400.6	425.1	446.1
Norway	1,412,975	198.6	247.4	254.6	264.4	274.7	356.1
Denmark	6,305,259	156.3	127.8	133.1	121.4	152.7	196.9
Finland	2,755,277	53.3	81.2	55.4	64.0	78.5	106.2

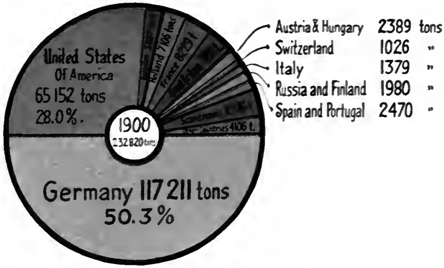
Relative Consumption of Actual Potash in Fertilizers in Different Countries

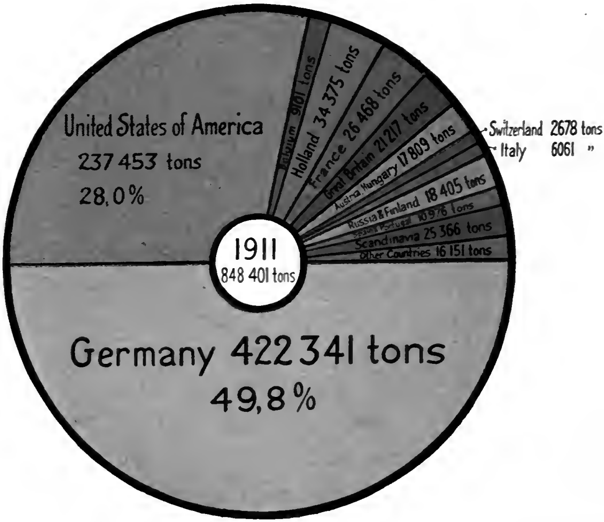




FLEET OF POTASH STEAMERS FROM HAMBURG TO NEW YORK HARBOR

Consumption of Potash
for Agricultural Purposes in Different Countries
In Metric Tons Pure Potash (K_2O)





The Importance of Potash in Agriculture

WHAT has heretofore been broadly stated with regard to the importance of potash in agriculture merits more detailed discussion and study. In almost every type of farming a considerable loss of potash takes place yearly, and unless the equivalent of this loss is restored in manures and fertilizers the reserve supply of natural potash in the soil will soon become seriously diminished, thus causing a shortage in the yield as well as defects in the quality of the crop. When crop after crop is removed from the same soil and sold away from the farm, either in the form of grain or livestock, the natural supply of plant food is gradually, but nevertheless surely, exhausted. In consequence of these losses in fertility the yields diminish year by year until a point is reached where lands once rich and profitable are being cultivated at a minimum profit and often at an actual loss. This gradual but surely diminishing productiveness of the soil is not confined to one country or one crop alone, but prevails universally wherever manures or fertilizers are not employed to replace the food elements removed by the growing crops. The practice of thus depleting the soil of its fertility, commonly termed "wearing out the soil" is now known to be due to the exhaustion of its supply of "plant food," which term is the one usually applied in speaking of the chemical substances essential to plant growth.

The three most important of the essential plant food ingredients are nitrogen, phosphoric acid and potash. All three of these ingredients are largely demanded by

growing crops and as the natural supply is limited, are usually found deficient in soils which have been cultivated for a number of years. The importance of these elements in the functions of plant life makes it imperative that everyone dependent upon the soil for a living should become familiar with their various functions, the sources of supply and relative values of each. Complete commercial fertilizers derive their comparative values from the adjustment of the percentages of these three elements to the needs of the several soils and the various crops grown. In this connection the word "essential" is deliberately used and is accurately applied in speaking of all three elements most deficient in average soils. The necessity of potash as an ingredient of plant food is just as great as that of nitrogen or phosphoric acid, which fact must not be overlooked in noting the prominence and amount of space devoted in this work to discussion of the importance and necessity of potash. Experiments carried out by Hellriegel and Wilfarth, in Germany, by Gilbert and Lawes, in England, and by many of the state experiment stations and scientists in the United States, have proven beyond doubt the necessity of potash compounds in plant growth.

The chief function of potash in plant life is known to be intimately concerned with several of the important forms of vegetative activity. The effect of potash compounds upon plant growth and products is evidenced in a number of different ways, which may be conveniently stated under separate headings as presented in the publi-

cation "Fertilizers and Crops" by Dr. Van Slyke, Chemist of the New York Agricultural Experiment Station, from which the following is freely quoted:

(1) Influence of Potash upon the Formation of Carbohydrates:

Potash is essential to carbon assimilation and in the absence of this element the manufacture of carbohydrates in the leaf and green parts of the stem is at once brought to a standstill. With the failure of this vital function all life activity ceases and plants wither and die. The formation of starch, sugar, cellulose and other carbohydrates which form the major part of all agricultural crops is absolutely dependent upon the presence of potash compounds within the body of the plant. Plants especially rich in carbohydrates contain much potash.

(2) Effect of Potash upon the Formation and Transference of Starch:

Experimental evidence indicates that potash compounds not only control the formation of carbohydrates, but also aid in the transference of starch from one part of the plant to another. Potash changes insoluble starch within the plant cells into sugar or other soluble compounds, in which forms it is able to gradually pass through the cell tissues and be transported to the fruit or seed, where it accumulates and changes back into its usual insoluble condition. In the absence of potash crops will not grow and starch will neither form in the chlorophyl grains nor move to other parts of the plant.

(3) Relation of Potash to Protoplasm:

Potash compounds appear to be intimately associated with the formation and activity of protoplasm within the plant cells; protoplasmic action is the basis of all life activity and growth, hence all controlling factors are of vital importance.

(4) Effect of Potash on Plant Cells:

Plant cells maintain the conditions of highest activity only when well distended or swollen, a condition technically known as turgor. Potash compounds are believed to be the mineral compounds mainly associated with this important action.

(5) Effect of Potash on the Growth of Roots, Stems and Leaves:

Potash compounds have a recognized importance in plant nutrition because of the marked influence exerted in the development of the fibrous or woody portions of the roots, leaves and stems. A deficiency of potash is quickly evidenced by a weak, brittle growth of root and stem and by a small and limited area of leaf and root systems. Trees plentifully supplied with available potash are able to grow firm, hard wood, and are therefore less liable to damage by cold and the attacks of insects.

(6) The Effect of Potash upon Root Crops and Fleshy Fruits:

It is well known that potash compounds are a requisite to the normal development of the fleshy portions of fruits, vegetables and all root crops. Comparisons of the analyses of the fruit, leaves and new wood of all of our

common fruits and root crops shows that the fleshy parts contain the greater portion of the potash present in the plant, thus substantiating the above statement. This effect is believed to be brought about through the intimate association potash has with the formation and activity of protoplasm within the plant cells. Potash is recognized as the dominant plant food ingredient for all root crops and fleshy fruits.

(7) Relation of Potash to Plant Acids:

Potash compounds are among the important mineral bases which help to neutralize plant acids and form the important acid salts to which the flavor and color of the edible portions of the plant is due. Thus potash is intimately connected with the high flavor and excellence in quality of fruits. The color of the flowering portions of blooming plants is directly influenced in intensity by the amount of available potash in the soil.

(8) Effect of Potash in Influencing Maturity:

A relative excess of potash compounds supplied to cereals and grass crops tend to prolong the period of the growth of the stems and leaves and thus delays the maturity of the crop. This is especially noticeable during a season of drought. With root crops and fleshy fruits the reverse is true since potash, through its effect on the transference of starch, hastens maturity and is thus often the means of saving crops from early frost.

(9) Effect of Potash on Leguminous Crops:

A widely recognized effect of potash is in its pronounced favorable influence upon the growth of leguminous crops,

such as clover, alfalfa, peas, beans, etc. It has been suggested that this is due to an indirect action of potash in promoting the growth of bacteria associated with the formation of the root nodules by furnishing them with an abundance of carbohydrates.

(10) Effect of Potash on Resistance to Disease:

Observations of many scientific investigators show that the lack of available potash in the soil is coincident with the appearance of various destructive plant diseases. This is especially true of vegetables and root crops, the cereals and grass crops. The conclusion is drawn that plants, if deprived of potash, become an easy prey to parasitic organisms, such as fungi and blights. It is evident that plants furnished with an unbalanced plant food, are apt to be weakened and in this condition their resisting powers are lessened until they become subject to the inroads of disease.

To the scientific reader the functions of potash in plant life enumerated above will make clear that this important ingredient of plant food is indispensable to the life activity of plants. To the practical farmer it will be of additional interest to note the more visible effects of using potash as a fertilizer which are therefore presented in the following condensed statements:

Potash improves both the yield and quality of all agricultural crops. A decidedly favorable effect is produced by potash in promoting the growth of clovers, alfalfa, beans, peas, etc., and in making the stalks of grain crops more firm and less liable to lodge. In grain crops the

weight per measured bushel is increased, a brighter, plumper berry is produced and the feeding and milling qualities improved.

In the case of hay and pasture grasses a marked improvement follows the application of potash fertilizers. Finer and more nutritious grasses replace the coarser varieties, the herbage is sweetened and the feeding value improved.

In the case of beets, potatoes and other root crops the sugar and starch content is increased and the proportion of "culls" reduced. Potash is recognized as the most important ingredient of plant food for all root crops.

Plants grown without potash make a weak, brittle growth of roots and stems and have small and limited root and leaf systems. Potash strengthens the woody parts of plants and grows trees with firm, hard wood, so that the danger of winter killing is greatly lessened.

The appearance, shipping and storing properties of grains, fruits and vegetables are favorably influenced by potash. Potash improves the burning quality and flavor of tobacco and thus controls the market price of the crop.

Potash strengthens plants and thus enables them to better withstand fungus diseases such as cotton blight and grain rusts, helps to ward off the attacks of harmful insects, such as grubs, wire worms and maggots which infest many crops. Kainit is the form usually employed in combating the attacks of insect pests and plant diseases.

The amount of potash required for the proper and best development of a crop depends upon the nature and weight

of that crop. Different growing plants have different appetites and necessities for potash and the amount of it which they have taken away from the soil can be accurately ascertained by chemical analyses. The following table shows the number of pounds per acre removed by an average yield of:

Grain and Hay in rotation..	75 pounds potash
Oats	62 pounds potash
Potatoes	74 pounds potash
Sugar Beets	143 pounds potash
Meadow Hay	85 pounds potash
Green Corn	164 pounds potash
Tobacco	103 pounds potash

A common four-year rotation in the northern states is corn, wheat, clover, timothy. By it the amount of potash taken from each acre is:

Corn, yielding 52 bushels...	82 pounds potash
Wheat, yielding 25 bushels..	35 pounds potash
Clover, yielding 2¼ tons..	120 pounds potash
Timothy, yielding 2 tons...	94 pounds potash
Total	331 pounds potash

This loss of 331 pounds of actual potash means an average of 80 pounds each year, or an equivalent of 160 pounds of muriate of potash. This must be replaced in the form of manure or fertilizer, or poverty of soil will rapidly follow.

Where the fodder is fed to cattle, and the manure returned to the soil, part of the potash contained in the crop is returned to the soil. If, on a farm of 100 cultivated acres, one-third of the required potash be thus returned (considerably more than is usually saved in ordinary farming), there still is 5,000 pounds of it annually removed from the farm, which must be replaced by some form of potash fertilizer, otherwise the original condition and richness of the soil cannot be maintained. More or less potash is naturally present in all soils, but, for the most part, in an insoluble and unavailable form, excepting that very small part which is freed annually and made accessible by the action of the elements. Even this original natural supply is limited, and were it all at once to be rendered soluble, it would quickly be leached out by rains and so completely lost.

In the beginning of vegetation easily soluble potash is absolutely essential, but it is not generally present in such form even in soils which contain a fair supply of total potash. The importance of potash salts in agriculture, therefore, is evident: Farmers must use them to make good the losses due to the growing and selling of crops. In this connection it is worthy of especial note that a part of the fertilizing substances contained in barnyard manure is insoluble, and so unavailable—useless as plant food.

Scientists and practical farmers agree that the by-products of the farm (farmyard manure) returned to the soil do not contain plant food in sufficient amounts or in

the right proportions to give the most profitable returns and the loss by cropping must be made good by applying chemicals: Nitrogen, in the form of nitrate of soda, sulfate of ammonia, tankage, fish scraps, etc., or by growing cow peas, clovers and other legumes, which absorb nitrogen from the air. The main source of the potash supply is the German potash salts, while mineral phosphates and bone products are depended on for phosphoric acid. Chemical manures have an advantage over those of the farmyard, in that they are readily available, cheaper and more agreeable to handle, besides being free from weed seeds and disease germs, which sometimes occur in the farm products.

Potash Salts for Fertilizing

THE most important of the potash salts used and in demand for agricultural purposes, with their percentages of actual potash, are:

	Minimum Per Cent Actual Potash	Pounds Actual Potash Per Ton of 2,000 lbs.
Muriate of Potash	48	960
Sulfate of Potash	47	940
Sulfate of Potash-Magnesia	25	500
Kainit	12	240
Manure Salt	20	400

The practical farmer is frequently confronted with the question: "Which of these potash salts shall I use, and how must I apply to get the best results?" The following explanations and suggestions help him to answer.

Muriate of Potash is the cheapest source of potash, particularly in sections remote from the seaports. This is because it is a concentrated article. One-half of its weight is pure potash, and it relatively costs much less in transportation than those products containing greater bulk and weight, but a lower percentage of potash. Muriate is the principal source of potash employed in commercial fertilizers and is well suited for most agricultural crops. It contains considerable chlorine (46 per cent.), which substance is considered injurious to the quality of smoking tobacco, for which crop sulfate of potash, although higher in price, should always be used. Many farmers likewise use sulfate in preference to the muriate on oranges, sugar cane, potatoes, fruits and tender vegetables, believing that the better quality produced compensates for the greater cost. However, deleterious effects on quality of the product can usually be avoided by applying the muriate of potash several months preceding the planting of the crop. By this previous application, the injurious chlorine contained in the muriate of potash is washed down by the rains into the subsoil, while the valuable constituent, potash, remains fixed in the surface-soil until it can be made use of by the growing plants. When muriate of potash is used regularly as a source of potash, it is desirable that the land receive a dressing of lime about once in five years. This will heighten the effect of the muriate.

Sulfate of Potash, and Sulfate of Potash-Magnesia. These potash salts, especially the first mentioned, are the safest potash fertilizers to use under all conditions. The

sulfate is always preferred for tobacco growing, also for oranges, sugar cane and tender vegetables. It deserves preference on soils inclined to be sour, and can be used in large quantities, for years in succession, without necessitating the use of heavy applications of lime, which are needed when muriate or kainit is extensively used. Sulfate of potash is a more expensive source of potash, and for this reason is not as universally used as the muriate of potash.

Manure Salt is another source of potash, of which it contains 20 per cent. It is similar in its effect to kainit and may be used instead, but neither one is recommended for tobacco, oranges, or in any case where there would be objection to muriate; in all such cases sulfate of potash or sulfate of potash-magnesia should be taken.

Kainit, as previously explained, is a raw product and contains only one-fourth as much actual potash as the muriate of potash. It is much cheaper per ton, though at a distance from the seacoast the potash in it costs more, pound for pound, than in the muriate, because of the freight and hauling which has to be paid on the whole mass regardless of the potash contained in it. It is frequently preferred to the muriate on account of its marked effect in ridding the soil of injurious insects (cut worms, root lice, white grubs, onion maggots, etc.). It is also highly esteemed in the cotton-producing states as a valuable preventive or remedy against "cotton blight." Manure salt, 20 per cent. potash, can be used for the same purpose. Mangel wurzel and other cattle beets and

asparagus are particularly benefited by kainit. It is most effective as a preserver of stable manure, and many practical farmers, though knowing that muriate of potash is cheaper, still prefer the kainit, because it is less concentrated, and requires less caution in mixing with other fertilizers and making composts. In sections 200 miles or more remote from the sea ports it may be so expensive (because of freight) as to make muriate of potash decidedly more economical. General experience has taught that on light soils its effects are very beneficial, but on heavy ones muriate or sulfate of potash is to be preferred.

The following table is arranged in two groups to distinguish between those potash salts which contain chlorids and those which do not:

CONTAINING CHLORIDS.	FREE FROM CHLORIDS.
Muriate of Potash.	Sulfate of Potash.
Kainit.	Sulfate of Potash-Magnesia.
Manure Salt.	

Those in the first group can be used with safety upon most agricultural crops, whereas those of the second should have preference for tobacco, oranges, or wherever special quality of fruit is essential, and wherever the more valuable result or return will justify the use of the higher priced fertilizer.

As previously explained, potash is only one of the three essential plant food ingredients; the others are phosphoric acid and nitrogen, and all three are of equal importance in plant life, although all are not required in equal amounts.

To make potash fully effective as a fertilizer, it is necessary to use it jointly with phosphoric acid and nitrogen, each in proper proportion. No one of these three ingredients can take the place of another in plant feeding, nor can an excess of any one compensate for a deficiency of a second. Potash salts should not be used alone, except in those cases when soils such as muck or peat soils are so rich in phosphoric acid and nitrogen, as compared with potash, that the latter alone is needed. In most cases, however, in order to produce the best effects, it is necessary to use potash salts jointly with material supplying phosphoric acid (acid phosphate, etc.) and nitrogen (nitrate of soda, fish and meat refuse, cottonseed meal and others). A mixture of these three ingredients is called a "complete fertilizer," and complete fertilizers, as sold in the market, should contain potash, phosphoric acid and nitrogen in different proportions to meet the demands of the various crops. Each farmer, therefore, must be governed by his particular needs in buying fertilizers. The value of the fertilizer, as already pointed out, depends entirely on the amount of potash, phosphoric acid and nitrogen it contains. If potash is bought separately, then the other two necessary plant food ingredients must be procured also, or else that which is supplied may be a practical waste and all crops fail. In the rational use of fertilizers, close attention must be given to the nature of the soil upon which they are to be used, since soils differ even from one season to another, depending on the preceding crops grown and what they have removed from the soil as well as on their

original formation and composition and the kinds of fertilizers previously used. All this must be made a careful study on the part of the farmer if he wishes to apply fertilizers to the best advantage and greatest profit.

In conclusion, every farmer is advised to study the work of the Experiment Stations in the different States, as they have been established for the purpose of carrying on practical field trials to find out which combinations of plant food are best suited to the various soils and crops. The results are of value and importance to all those who earn their living by tilling the soil. Time, money and labor can be saved in this way, but the real progressive farmer will not only keep himself informed about the experiences of others, but will also, to a certain extent, experiment on his own account, to learn which methods of cultivation, rotation and fertilization can be practiced with the greatest benefit and profit to himself. But whatever his conditions, potash—the producer of starch, sugar and strength of fiber, flavor and shipping quality—must not be allowed to run down in the soils which grow his crops.

Comparative yield of Corn on farm of Fred Lightheart, Francesville, Indiana.

Fertilized with 500 lbs. per Acre. 2% Nitrogen, 8% Phosphoric Acid, 10% Potash. Yield per acre, 75.7 bushels.	Without Fertilizer. Yield, 32.1 bushels.

Fertilized with 200 lbs. per Acre, Muriate of Potash. Yield per acre, 73.4 bushels.	Without Fertilizer. Yield, 32.1 bushels.

The yields illustrated in two above photographs were secured on a black sandy soil abundantly supplied with nitrogen, phosphoric acid and humus, but deficient in potash. On this soil potash alone was the most profitable. The addition of nitrogen and phosphoric acid to potash only increased the yield 2.3 bushels, which did not pay for the added cost of the nitrogen and phosphoric acid in the fertilizer.

SWEET POTATOES FERTILIZED WITH PHOSPHORIC ACID AND NITROGEN. YIELD PER ACRE: 122½ BUSHELS

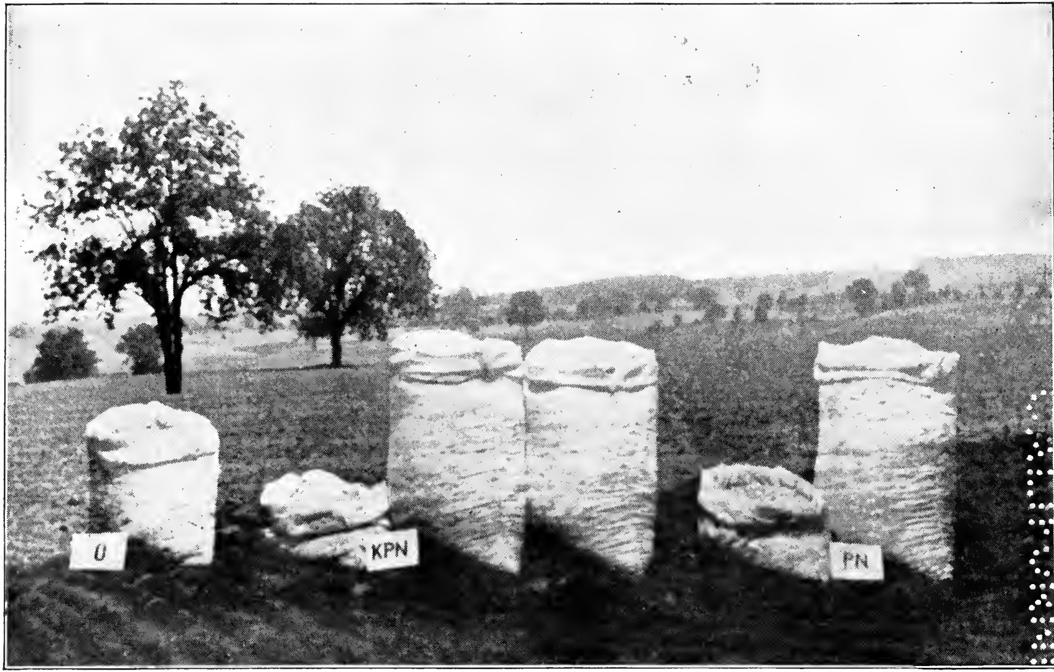
EXPERIMENTS MADE AT SOUTHERN PINES, S. C.

SWEET POTATOES FERTILIZED WITH POTASH, PHOSPHORIC ACID AND NITROGEN. YIELD PER ACRE: 250 BUSHELS

EXPERIMENTS MADE AT SOUTHERN PINES, S. C.

KIEFFER PEARS ON H. H. SWAIM ORCHARD, SOUTH BEND, INDIANA

Nitrogen and Phosphoric Acid	Nitrogen, Phosphoric Acid and Potash.	Unfertilized.
Yield per acre, 86.1 bushels.	205.8 bushels.	58.8 bushels.



BEANS GROWN BY S. J. HANNA, MASON, MICHIGAN

Unfertilized.	Nitrogen, Phosphoric Acid and Potash.	Nitrogen and Phosphoric Acid.
Yield per acre, 5 bushels.	22.7 bushels.	13.3 bushels.